AMERICAN ENGINEER AND RAILROAD JOURNAL.

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CONTENTS.

LOCOMOTIVE DESIGN.

By F. J. Cole, Mechanical Engineer Rogers Locomotive Works.

Equalization of Weights.

(Concluded from page 70.)

The mogul type of engine has a two wheeled radial truck in front and three pairs of coupled driving wheels. The spring arrangement is shown in Fig. 7. There are three points of support, one at B, the fulcrum of the truck equalizer, and two at A (one on each side) the fulcrums of the equalizing levers between the main and back wheels. The back end of the front driving spring is fastened to the frame, while the front end is connected by means of a cross beam to the truck equalizer. In Fig. 7 the longitudinal center of gravity of the engine above the springs is located 63 inches ahead of the equalizing lever fulcrum of the main and back wheels. This is determined as follows: From the weights of each pair of wheels resting on the rails, is deducted the weight of the wheels and axles with the parts carried directly by them, such as eccentrics, eccentric straps, part of the eccentric rods, driving boxes, back end of main rod, etc. This leaves a net load of 24,000 pounds on each pair of driving springs or 48,000 pounds for the two rear pairs of wheels. One-quarter of this or 12,000 pounds is carried by each pair of front and back spring hangers of the back and main driving springs, and one-half or 24,000 pounds is carried by the equalizer fulcrums at AA. The common center of gravity of the combined weights carried by the main and back wheels is also at AA, midway between the wheels. It is evident that the weights on each of these wheels are the same because the springs are connected by levers with equal arms. A weight of 12,000 pounds is carried by the forward ends of the front driving springs and 11,000 pounds by the truck. The proper location of the fulcrum, B, to give the respective weights on either ends of the truck equalizer, may be found by multiplying the total length of the lever by the weight on the truck and dividing this product by the sum of both the loads; the quotient will be the length of the back portion. Thus

$$\frac{11{,}000 \times 78}{23{,}000} = 37.$$

The common center of gravity of the load on the truck

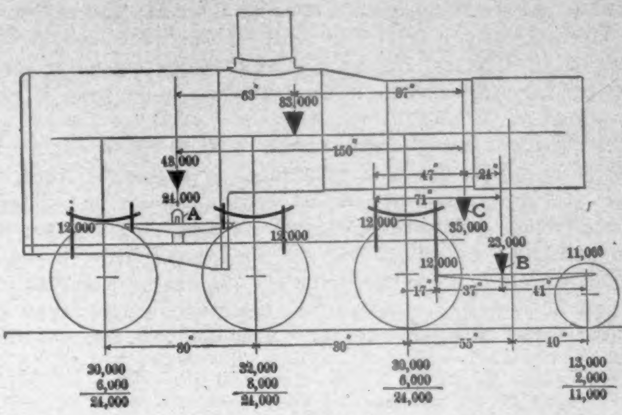


Fig. 7

Wheel Loads and Arrangement of Equalizers for Mogul Engines. The weights given are for both sides. For one wheel take one-half the load.

equalizer at B and that on the back hanger of the front spring. 23,000 and 12,000 pounds respectively, is found in a similar manner to be at C, 47 inches from the back hanger or 30 inches from the center of the front driver. The two centers, A and C, which are 150 inches apart, may now be combined. The rear one, A, equals a load of 48,000 pounds and the front one, C, 35,000 pounds, making a total of 83,000 pounds. The common center of gravity is found to be 63 inches from the fulcrum A. To obtain equal weights upon each wheel with the wheel base and weight on the truck as given in Fig. 7, the center of gravity must be located in the position shown. If this is not done no amount of subsequent adjustment of the equalizing levers will produce a uniform distribution of weight upon all the drivers and give the proper proportion upon the truck. Considerable variation of weight upon the truck may be effected by changing the position of the lever fulcrum, B, but this only serves to change the relation existing between the front wheel and the truck, which does not materially affect the other two pairs. It follows then, that if the sum of the loads on the truck and front wheels are not sufficient the deficiency can not be made up in any other way than by altering the

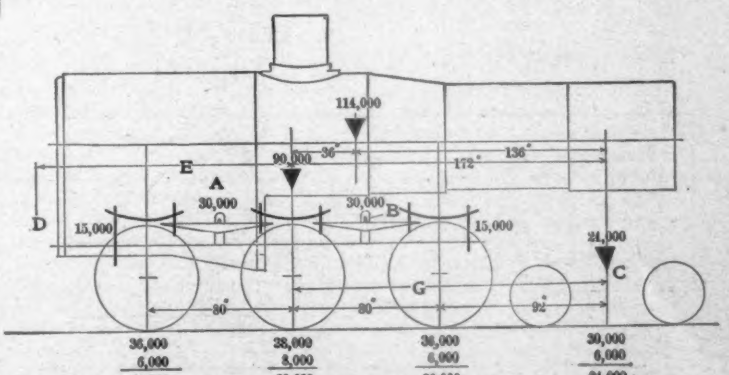


Fig. 8

Wheel Loads and Arrangement of Equalizers for 10-Wheel Engines. The weights given are for both sides. For one wheel take one-half the load.

position of the center of gravity of the entire superstructure, either by shifting its position bodily or by a readjustment of some of the heavy parts. It will be readily observed that within the limits of the ordinary designs of mogul engines the weights carried by the main and back wheels are equal, as the springs are connected by equalizing levers with similar arms.

For a predetermined truck weight the weights carried by the front driving wheels will only equal those of the main and back, when the position of the boiler and its attachments, etc., is so located as to bring the center of gravity in the correct

position. When the firebox is between the main and rear axle the average weight is 17 per cent. on the truck and 83 per cent. on the drivers, and with a long firebox extending over the rear axle, 14 per cent. on the truck and 86 per cent. on the drivers.

The spring rigging arrangement of a 10-wheel engine is shown in Fig. 8. In this type there is a 4-wheel truck in front and three pairs of coupled driving wheels. The three driving wheel springs on each side are connected together by two equalizing levers so that the weight supported by each pair of wheels is the same, irrespective of the overhang of the firebox, or excessive weight of the back end. In this type, as in the 8-wheel type, there are three fixed points in the equalizer

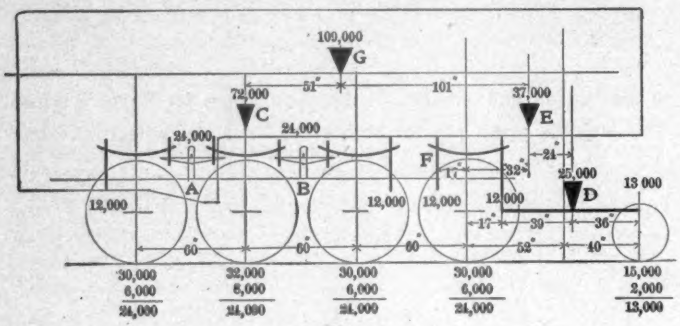


Fig. 9

Wheel Loads and Arrangement of Equalizers for Consolidation Engines.

The weights given are for both sides. For one wheel take one-half the load.

system, the truck center C and two centers of equalizers, although the frames are supported at four points or fulcrums instead of two as in Fig. 7.

When the firebox is between the main and rear axles the average weight is 26 per cent. on the truck and 74 per cent. on the drivers. When the firebox extends over the rear axle the average weight is about 22 per cent. on the truck and 78 per cent. on the driving wheels. The effect of changes in weight in the simplest form may be considered by supposing an increase of weight of 1,000 pounds at D. The increase on the drivers will equal $\frac{1{,}000 \times (E + G)}{G + (\frac{1}{2} F)}$.

The decrease on the truck will equal $\frac{1{,}000 \times E}{G}$.

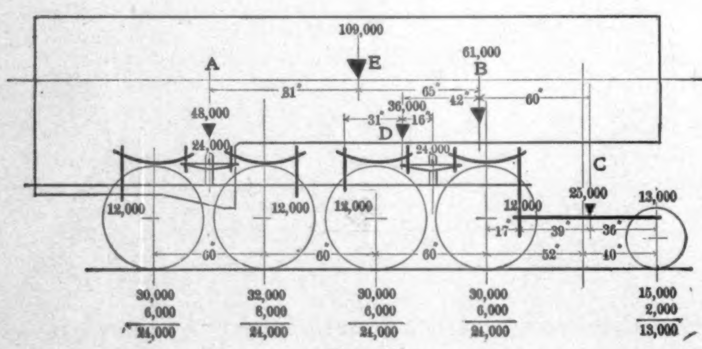


Fig. 10

The consolidation type of locomotive has a 2-wheeled radial truck in front and four pairs of driving wheels. The ordinary form of spring arrangement is shown in Fig. 9. Three pairs of driving wheels, the second, third and fourth, are equalized together, therefore, the loads carried by these wheels are the same. The equalizer lever fulcrums **are at A and B,** each of them carry 12,000 pounds or 24,000 pounds for both sides, as shown in the diagram. As these three pairs of driving wheels are spaced an equal distance apart, the center of gravity of the sum of the weights on these drivers will be located midway or over the center of the main wheels at C.

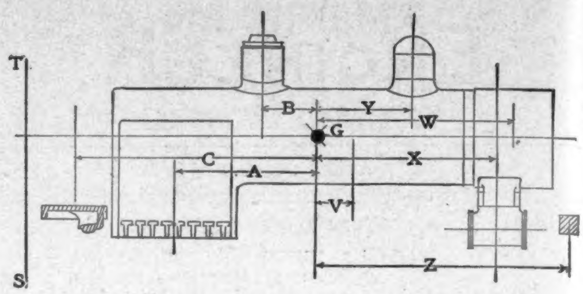


Fig. 11

The center of the truck fulcrum is at D, 39 inches from the front spring hanger or 56 inches from the center of the front wheel; the sum of the weight on the truck and that of the front hanger of the front spring, 13,000 + 12,000 = 25,000 pounds, is carried at this point. The common center of gravity of the weights at D and F, 25,000 + 12,000 = 37,000 pounds, is located at E, 49 inches from F, or 32 inches in front of the forward wheel.

The common center of gravity of the weights at C and E, 72,000 + 37,000 = 109,000 pounds, is located at G, 51 inches ahead of the main axle. When this arrangement of equalizers is used, the extreme range is 51 inches from the position G, where the weight is equally distributed on all the drivers with a suitable ratio on the truck, to position C, where all the weight would be carried on the three rear pairs of wheels, and none on the front pair of drivers and on the truck. The range ahead from G to E is 101 inches. At position E all the weight would be carried on the front pair of driving wheels and on the truck and none on the three back pairs of driving wheels.

The arrangement of equalizers shown in Fig. 10 is often used for consolidation engines which are too heavy behind. The springs on the main and rear driving wheels are con-

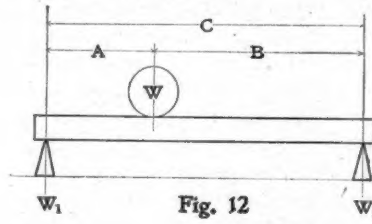


Fig. 12

nected by equalizing levers. The fulcrum is at A and the center of gravity of the weight (48,000 pounds) carried by these two pairs of wheels is at the same point. The forward center of gravity of the weights on the truck and the two front pairs of drivers (61,000 pounds) is at B, 60 inches back from the truck fulcrum, C. The common center of gravity of the combined weight at A and B is located at E, 81 inches ahead of A or 51 inches ahead of the main wheel. This is the same position as shown in Fig. 9, therefore to get an exactly equal distribution of weight on all the driving wheels and the same ratio on the truck, the center of gravity must be the same, irrespective of the arrangement of equalizing levers, provided they have arms of the same length.

The advantage of this arrangement in Fig. 10 consists in the fact that the range is 81 inches backward before the entire load would be carried on the two rear pairs of driving wheels and none on the front pairs and on the truck, whereas in Fig. 9 the range was only 51 inches. Therefore, for narrow gauge engines with fireboxes behind the rear axles and for other consolidation engines of ordinary builds which are too heavy behind, there is some advantage in this plan.

With one axle under the firebox the average weight is 11 per cent. on the truck and 89 per cent. on the driving wheels. With two axles under the firebox the average weight is 14 per cent. on the truck and 86 per cent. on the driving wheels.

Often the weight on one pair of wheels is the limiting factor in the design of a new locomotive. The size and power of

the engine must then be made to conform to some maximum wheel load. In order to obtain the greatest efficiency consistent with this limitation, the weights on all the driving wheels should be made as nearly alike as possible. It is, therefore, desirable in such cases where all the driving wheel springs are not connected by equalizing levers to locate the center of gravity of the superstructure carried by the springs, so that all the driving wheel loads will be the same. Then proceed to locate the boiler and other heavy parts in such positions as will produce the desired results.

To ascertain whether an engine balances at G, the theoretical center of gravity, Fig. 11, the weight of each part and its distance from G must be known. The boiler should be divided into convenient sections whose centers of gravity can be easily found. For instance the back end, including the firebox, grates, etc., naturally group themselves together at A. The cylindrical part, including the flues, makes another group at Y, and the smokebox a third part at W. Multiply the weight of each group or part by the distance of its center in inches from G, and put down the results for either right or left hand in separate columns. If the totals are the same the distribution is correct. If the totals are unequal, take the difference between the amounts and divide by the total weight, the quotient will be the distance in inches of the actual center of gravity to the front or rear of G. Example:

Left.		Right.	
C = 150 × 400 =	600,000	W = 130 × 2,000 =	260,000
A = 100 × 18,000 =	1,800,000	V = 24 × 15,000 =	360,000
B = 20 × 2,000 =	40,000	X = 125 × 12,000 =	1,500,000
		Y = 50 × 150 =	75,000
24,000	2,440,000	Z = 150 × 1,000 =	150,000
		31,500	2,345,000

The difference between the totals is 95,000. The total weight is 24,000 + 31,500 or 55,500 pounds $\frac{95,000}{55,000} = 1.71$ inches. Therefore, the actual center of gravity is 1.71 inches ahead of G the theoretical. In order to exactly equalize the weights, an amount must be added or taken from either side whose weight multiplied by its distance in inches equals 95,000, or the position and weight of some of the parts must be readjusted.

To obtain the center of gravity of the weights for either side divide the total product by the sum of the weights for that side. Then for the weights and distance given in Fig. 11

$$G_R = \frac{2,440,000}{24,000} = 101.6 \text{ inches.}$$

$$G_L = \frac{2,345,000}{31,500} = 74.4 \text{ inches.}$$

Another way to find the center of gravity of a number of weights is to measure the distance of each from some fixed point outside the group (as for example the vertical line, ST, Fig. 11). Then multiply the weight of each part or group by its distance from the line ST. Add the results thus found for all the weights together and divide by the total weight of all the parts, the quotient is the distance of the common center of gravity from the line ST.

In Fig. 12

$$A = \frac{W_2 C}{W} \qquad B = \frac{W_1 C}{W}$$

$$W_2 = \frac{AW}{C} \qquad W_1 = \frac{BW}{C}$$

The above formulas will be found useful in determining the proper position of equalizing lever fulcrums, when the arms are made of an unequal length in order to carry more weight on one end than the other. Also to locate the truck equalizer fulcrums of mogul or consolidation engines.

EDITORIAL CORRESPONDENCE.

Buffalo, Rochester & Pittsburgh Railroad.

The shops of this road at Rochester are not modern, and they will soon be replaced by a suitable plant in which the best facilities will be provided. The amount of work turned out is very creditable to Mr. C. E. Turner, Superintendent of Motive Power and his assistants.

The piston valve as applied to a number of engines by the Brooks Locomotive Works has earned a high place here, and it is doubtful whether the slide valve will be used on future orders. Mr. Turner is decidedly pleased with the central admission feature and believes that the protection of the passage for the entering steam from radiation by being placed between the exhaust steam passages is a very valuable improvement. He made a point of the fact that this arrangement necessitated crooked exhaust passages and consequently larger ones than would be needed if they were as straight as in the case of slide valves. This is provided for in the Brooks design by a slight extension of the ends of valve casings to give room for larger passages at the ends. There is no objection to this, and it seems to overcome a little of the back pressure which, however, has not been excessive with this form of valves. The crooked passage needs to be made larger than the straighter one. The location of these valves in the saddles instead of upon the tops of the cylinders makes it easy to protect them from radiation, and in these engines the saddles are lagged to a higher point than has been accomplished before.

Mr. Turner has given a great deal of attention to the design of cars of large capacity to adapt them to the special conditions of the coal, coke, and ore traffic of the road. On looking over the drawings, it was seen that the castings, which were all of malleable, iron are remarkably light, and where possible the fiber stresses were kept down to 4,000 lbs. per square inch. This was determined upon after tests of the material showing it to be safe to count upon an elastic limit of 30,000 lbs. and ultimate strength of 40,000 lbs. In spite of the low allowable working stress of but 4,000 lbs. the castings generally weighed so much less than cast iron that notwithstanding the advantage of 43 per cent. difference in price in favor of cast iron at the time of the design the cost of the malleable was less than that of cast iron. The total weight of malleable castings in cars of 80,000 lbs. capacity in spite of the additional castings required in the heavy bolsters of the large cars, is less than that of the cast iron formerly used in cars of 40,000 lbs. capacity. A characteristic of Mr. Turner's car designs is the use of deep trusses. In one case he has brought the truss rods to within 10 inches of the rail, the truss being 27½ inches deep.

Mr. Turner has for some years used a convenient form of jig for laying off car timbers of all kinds. These are cut to the desired shape and upon side they carry pointed plungers in tubes supported over holes in the jig. These plungers may be struck through the holes by hand to mark the centers of bolt holes and mortises. Each plunger is marked with the size of the hole. This greatly reduces the labor of marking out the timbers. A number of convenient air tools have been developed here, among which is Mr. Turner's flue cutter and roller, which is now well known. It has recently been fitted with an ingenious governor which automatically reduces the speed of the motor, and saves air when it is not actually rolling or cutting.

Chicago, Burlington & Quincy.

A good suggestion was received during a call upon the Superintendent of Motive Power of this road. He prepares an annual report covering the important work of the year, to enable him to keep track of the work of the department, the condition of its equipment, and to afford a review of progress that has been made. This fixes dates of important changes and improvements, and it appears to be an excellent plan. The idea was a new one to our correspondent. Its chief recommendation seems to be that it brings up the work of a year in condensed form and is suggestive of the lines which have proven advantageous in the past and which will probably pay to follow in the future. It must necessarily take considerable thought, and if a man analyzes his own work in order to set forth that which has been most valuable he will probably see ways in which to improve it.

The cost of doing work is considered as most important information on this road. Recently the entire cost of building locomotives has been thoroughly investigated and the information tabulated with great care and thoroughness. The lack of exact knowledge as to the shop costs of work on railroads is noticeable, and very few foremen have the slightest idea of the cost of various shop operations. Under present conditions this information is invaluable, particularly in connection with the introduction of new machinery. A man who knows what his work now costs and how much he can save by a new machine, has a strong argument with the management when he asks for appropriations for new machines.

The appointment of an inspector of oiling has proved a paying investment on this road. A reduction of the cost of oil for cars and locomotives amounting to over $2,000 in three months was secured, and at the same time there was a large reduction in the number of hot boxes and in the amount of waste used. There was a small increase in the number of brasses used, but brasses have a scrap value to offset this. The use of more brasses is due to an attempt to lead the inspectors to understand that a hot box needs attention, and usually something more than oil is required to prevent it from heating again. The pursuit of the hot-box problem on this road is persistent and systematic. The results indicate that a large amount of the trouble may be easily overcome.

Fig. 1.—80.000 Pounds Capacity Steel Frame Coal Car—Norfolk & Western Railway—With Test Load.

W. H. LEWIS, *Superintendent Motive Power.* C. A. SELEY, *Mechanical Engineer.*

80,000-POUND STEEL-FRAME COAL CARS WITH DROP DOORS.

Norfolk & Western Railway.

Frames of Structural Steel With Wooden Floors and Siding.

This road has in service the larger part of a lot of one thousand 100,000-pounds capacity copper-bottom coal cars, with steel under frames and wooden hoppers, the design of which was illustrated and described in the June, 1899, issue of this journal. Through the courtesy of Mr. W. H. Lewis, Superintendent of Motive Power, and Mr. C. A. Seley, Mechanical Engineer of the road, we have received drawings and information concerning a new design of a somewhat different type of car, from which this description is prepared. The chief dimensions of the car are as follows:

General Dimensions.

Length, over buffer blocks	36 ft. 6½ in.
Length, over end sills	35 ft. 1 in.
Length, inside of box	33 ft. 0 in.
Width, over side sills	9 ft. 1 in.
Width, inside of box	8 ft. 9½ in.
Height, inside of box	4 ft. 6 in.

In the present design, as will be seen from Figs. 3 and 4, advantage has been taken of the opportunity afforded by the box of the car having full sides of considerable height, to introduce a truss to support the sides, thereby using very light side sills and dispensing with the stakes ordinarily used. The small light weight of the car is largely due to this feature of the design.

The truss members are 5-inch channels of the necessary weight required by the loads at the various panels. The bottom chord or side sill is an 8-inch 11½-pound channel, the top chord is a heavy angle, and ½-inch by 6-inch gusset plates are also used for the upper connections. The angle also serves as a coping for the wooden lining of the car.

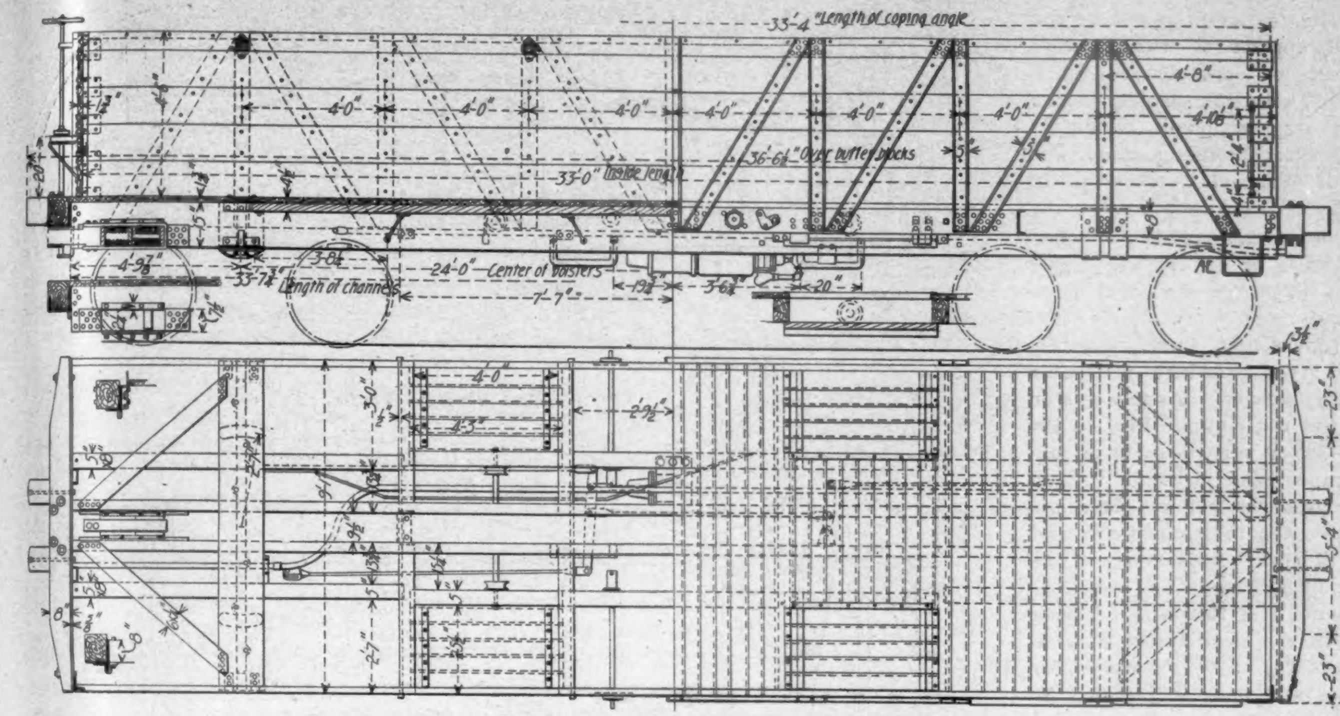
The center sills are 15-inch, 33-pound channels, secured to the end sill plates and body bolster members by angle irons, and it will be noted that the full strength of the flanges has been preserved by making all holes for connections through the webs of the channels. The body bolsters are located 4 feet 10 inches from the outside ends of the sills and are designed with steel plates and malleable-iron fittings, riveted up in such a manner as to secure the necessary rigidity.

All of the material used in the construction of the car is in the form of standard rolled sections or regular sizes of bars or plates, no special or unusual sizes being employed. All attachments, such as drop-door hinges, cross-sill supports and brake fixtures, are riveted on. In order to provide door pockets and immediate floor support, a system of short wooden intermediate and cross sills, 5 by 8 inches, are used as shown in the plan view of the car, Fig. 2. These sills are grooved for 1 inch through tie rods.

The lining of the car is of 1¾-inch pine, and the floor, of which there is an area of 287 square feet, is of the same material, 1¾ inches thick by 6 inches wide, and ship lapped. Owing to the height of the sides of the box of the car and the lateral pressure of coal as lading, four 1½-inch top cross tie rods are used to prevent bulging. These, however, will not prevent using the car for lumber. Four drop doors, 48 by 27¾ inches, are provided, which are handled by winding shafts, chains, ratchets and locks, similar to those generally used in such equipment. The doors are so located as to dump a large proportion of the contents of the car when dumping is desirable. The car is equipped with Westinghouse air brakes, the design of the underframing permitting a very simple direct brake system. The couplers are arranged with tandem springs and the draft lugs are riveted direct to the center sills.

This car was designed to take a lading of 88,000 pounds and not to exceed 10,000 pounds fiber strain in its members. The test load of the sample car was wet coal, and when well heaped up weighed 92,700 pounds. This was subsequently increased by heavy rains to 95,250 pounds. Under this load the deflection of the center sills was ¼ inch, and that of the sides was not quite ⅛ inch.

The car, as shown in Fig. 1, is mounted on a pair of diamond



80,000 Pounds Capacity Steel Frame Coal Car—N. & W. Railway.

Fig. 2.—Plan and Longitudinal Section.

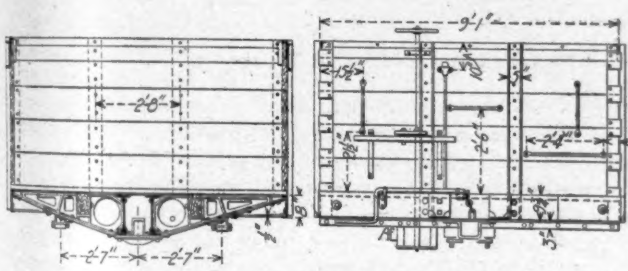
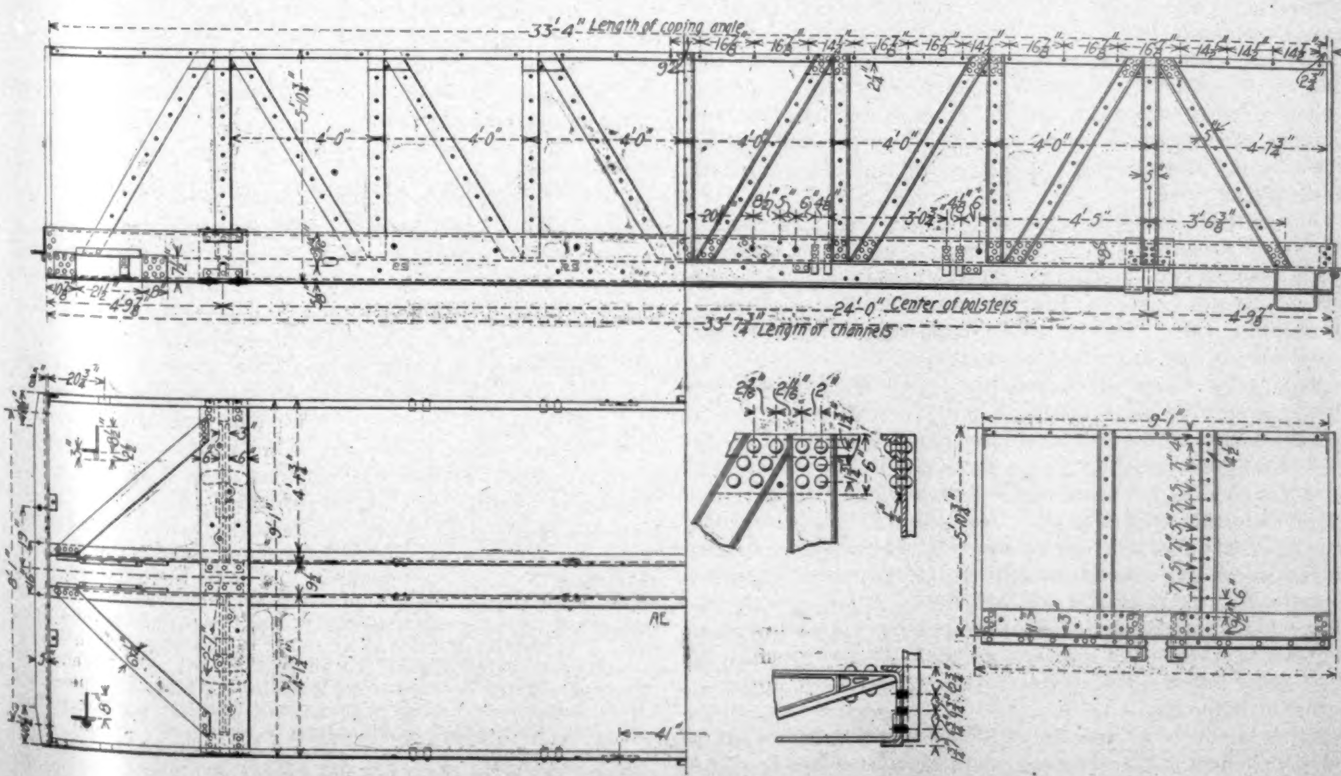


Fig. 3.—Transverse Section Showing Bolster.

type trucks, standard to the 50-ton cars. At the time the car was built the standard truck for 80,000-pound cars had not been designed. With these heavy trucks the weight of the car is 33,700 pounds, but with the new trucks this weight will be reduced to 32,000 pounds or less.

The new design of truck shown in Figs. 5 and 6 is similar in many respects to those under a large proportion of the N. & W. rolling stock. It is 6 inches shorter in wheel base than is used in the trucks under the 50-ton cars, which admits of light top arch bars, 4½ by 1½ inches, while the inverted bars are 4½ by 1⅜ inches, and the tie bars 4½ by ½ inches.



80,000 Pounds Capacity Steel Frame Coal Car—N. & W. Railway.

Fig. 4.—Plan and Elevation of Steel Framing.

The lightening process has also been applied to the bolsters, which are 10-inch 35-pound I beams, with iron spacing blocks, to the spring plank, which is a 12-inch 20.5-pound channel, and to all other details where consistent with good design.

The journals are 5½ by 9 inches, the same as are in use under N. & W. 50-ton cars, which, although not M. C. B. standard for that weight, have, nevertheless, given excellent and satisfactory service. As may be seen by the illustration, Fig. 1, the car has a very neat, trim appearance, and although its service test has not yet been extensive, the indications are that it will be very satisfactory. The Norfolk & Western are preparing to build one thousand of these cars in the near future at Roanoke. The use of wood for lining and floor is justified by the designers by the unfavorable action of the acids and moisture in coal, and owing to the use of standard sections the repairs will be greatly facilitated.

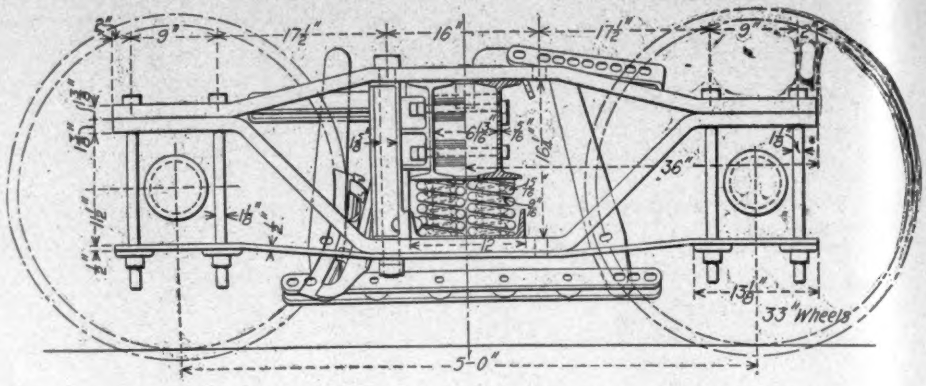


Fig. 5.—Side View of Truck.

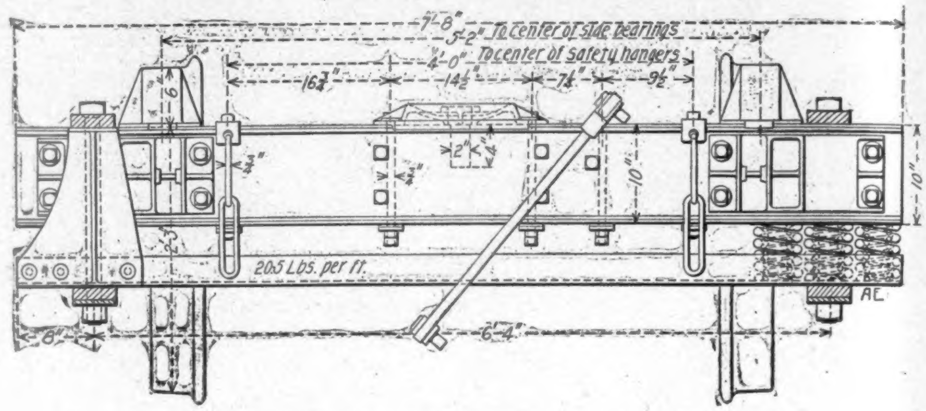


Fig. 6—End Elevation and Section of Truck.

A CONTINUOUS MEAN PRESSURE INDICATOR.

A method of obtaining a continuous record of the mean pressure in a steam engine cylinder by pressure gauges was brought before the Institution of Mechanical Engineers about two years ago by Prof. William Ripper and described in our issue of October, 1897, page 355. Prof. Ripper's plan is to use valves driven from the engine to keep a steam gauge in communication with the steam side of the piston while another gauge is kept in communication with the back pressure side. The valves simply act to throw the gauge into communication with the ends of the cylinder alternately so that one gauge is always connected to the steam side and the other to the exhaust. For complete records of his work the paper may be consulted as reprinted in "Engineering," December 15, 1899, page 771, and the following issue.

This method seems to give surprisingly accurate results. The mean pressures are read on the gauges and to obtain a steady reading two throttling cocks are used, one close to the valve, referred to above, and the other close to the gauge. Prof. Ripper says: "By the use of these regulating cocks the oscillations of the finger of the gauge may be reduced to any desired degree of steadiness without interfering with the accuracy of the reading of the mean pressure." Despite the fact that the author of the paper expects engineers to object to the method as inaccurate for the determination of such an important factor as the mean effective pressure of an engine, he has come to the conclusion that "readings by a pressure gauge may be obtained which are as accurate, as consistent and as reliable as by any known instrument for the measurement of pressure, not excepting the best of indicators; also that throttling, when properly applied, does not endanger the accuracy of the reading, but, on the contrary, gives the true mean effect of the regular successions of momentary variations of pressure acting on the gauge."

This idea will be accepted rather conservatively because it is radical, though it may prove to be absolutely correct. The throttling and gauge method would be a boom to those who test locomotives either on the road or on rollers, because of the advantage of having a continuous record. This is equally applicable in the case of any form of high speed engine with fluctuating load. In case the power of any engine changes rapidly it is impossible to obtain a record with an indicator even if a large number of diagrams are taken on one card because of the difficulty of averaging their areas. In the discussion attention was called to the fact that ordinary indicator diagrams are often taken on so small a scale that it is almost impossible to read pressures accurately and the thickness of a line represented one pound pressure. Prof. Ripper's instrument was considered to be as accurate as that.

This appears to be an important suggestion with reference to the measurement of power.

TEST OF AN ARCH BAR TRUCK FRAME.

An arch bar truck side frame was recently tested to destruction by Prof. C. V. Kerr, of the Armour Institute of Technology, Chicago, and the results were presented last month before the Western Railway Club. Three series of loads were applied by means of a 200,000 lbs. Riehle testing machine, the car journals were represented by a short piece of shafting and the loads were applied by means of short lengths of I beams. The first series begun at 4,900 lbs. and gradually increased to 45,000 lbs. Upon release the permanent set was about 1-5 in. The several series carried the load up to 75,000 lbs. with a permanent set of a little less than 0.4 inch. The load was then increased to 99,500 lbs., at which one of the journal boxes broke. A further increase of load to 155,800 lbs. caused the bolts to shear and the boxes to crumble. The boxes were not standard M. C. B. boxes but were cut away in such a manner as to weaken the structure considerably, and the frame failed sooner than it otherwise would. Prof. Kerr, as a result of this test, strongly advocates lipping the under arch bar over the ends of the upper bar in order to reinforce the bolts against shearing. The stresses imposed upon this truck frame are greater than any static load which would occur in actual service, but since it is clear that the frame tested was weakest in shearing strength the point made is a good one and it should be considered more generally than is now the case in the construction of diamond trucks.

PRAIRIE TYPE AND WIDE FIREBOX SWITCH ENGINES.

C. B. & Q. Railroad.

Prairie Type.

General Description.

The locomotive design which we illustrate herewith is one of unusual interest because it is a rather bold step in breaking down the too thoroughly established custom of adhering to narrow fireboxes for soft coal burning engines. This design was prepared and several of the engines are being built by the motive power department of the Burlington road. They are intended for service in which the capacity of the boiler governs the load hauled. They are to be used on lines with low grades, and in heavy freight service, at low speed, or for stock and merchandise trains at high speeds.

The name "Prairie Type" and designation "Class R" have been given to this engine, which is a mogul, with a pair of trailing wheels under the firebox. The novelty of the design is the combination of a wide yet deep firebox, inside frames back to the firebox, and outside frames under the mud ring. The firebox is 7 feet long and 6 feet wide. This appears to be very short, but it will certainly make the fireman's work relatively easy, and if made longer the weight on the trailers would be increased. The grate area is 42 square feet, and the question may be asked as to why it was not made larger. We are so accustomed to the extremely large grates used for anthracite coal that this grate area seems small. It is to be used for bituminous coal, and western coal at that. The experience of the Burlington with Wootten boilers some years ago has led the officers to believe that this grate area will be successful with their coal, and that it will serve to indicate the proper direction to take in future construction. It is a generous increase over usual practice, and yet it stops short of extremes.

The elevation and half plan, Fig. 1, illustrate some of the difficulties of the frame construction. The grate was placed low in order to secure depth in the firebox, and the frames were dropped at the back of the rear driving boxes as low as practicable without interfering with the height of the draft connection to the tender. The boiler drawing, Fig. 2, shows the mud ring to be 18 inches below the throat. The main frames stop under the front end of the firebox, where they are attached by keys and bolts to a heavily ribbed cast-steel cross bar, shown in Fig. 5.

Short sections of frames, with pedestals for the trailing wheels, are spliced to the cross bar, and these frames were made wider than the main frames in order to give a good arrangement of the ash pan, which is seen in Fig. 3. The journal boxes for the trailing wheels are outside of the wheels and the frames are under the mud ring. With such a low mud ring this widening of the frames seems to be necessary. The possibility for a hinge action of the frames at this cross bar is very naturally suggested by this construction. This has been considered in the design of the bar, which is strongly ribbed on both sides. The bar itself, and the frames, at the splices, are 16 inches deep, and the splices each have 12 1⅛-inch bolts. In the plan view of Fig. 1 and in Fig. 5, the form of the splice is shown. The parts are so fitted as to bring the keys in compression instead of shear. This is a very strong splice. Attention was directed to this method of keying on page 181 of our June issue, 1899. It has been in use on the Pennsylvania since 1892 and we hope it will come into general use for frame splices. The rear cross bar, also of cast steel, in which the draft iron is an integral part, is shown at the left in Fig. 5. This construction necessitated tubes 16 feet 1 inch long, although they were favored as much as practicable by the location of the tube sheets. The equalizer system and spring rigging are shown in Fig. 1. The front driving wheels are equalized with the truck, and the remaining wheels are equalized together. The trailer journal boxes have

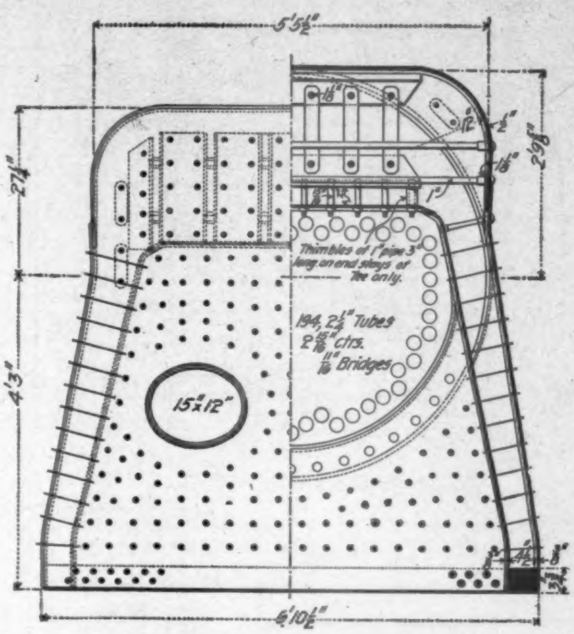


Fig. 2a.—Section of Firebox of Class R, "Prairie" Type Locomotive, C. B. & Q. R. R.

slings carrying saddles, upon which a pair of equalizers rest. The back ends of these equalizers are connected to the frames by coil springs, while the front ends are connected across the engine by a long transverse equalizer to which the equalizers which are fulcrumed under the cross bar are connected by links. This complicates the spring rigging, but it is necessary on account of the lateral offset in the frames. It is claimed, however, by the designers that the outside bearing on the trailing axle and this cross equalizer will both tend to increase the stability of the engine and diminish "rolling" or "lurching" even on soft or uneven track.

The most important dimensions are given in the following table:

Prairie Type Locomotive.
C. B. & Q. R. R.

Gauge of track	4 ft. 8½ in.
Cylinders	19 by 24 in.
Driving wheel centers	56 in.
Thickness of tires	4 in.
Engine truck wheels	37 in.
Trailing wheels	37 in.
Driving wheel base	11 ft. 4 in.
Firebox, inside	7 ft. by 6 ft.
Boiler, diameter at front end	56 in.
Boiler, diameter at throat sheet	66 in.
Heating surface, tubes	1,827 sq. ft.
" **firebox**	131 sq. ft.
" **total**	1,958 sq. ft.
Grate area	42 sq. 5t.
Weight of engine in working order (estimated)	138,000 lbs.
Weight on drivers (estimated)	94,000 lbs.
Weight of tender in working order (estimated)	96,000 lbs.
Tender, water capacity	5,000 gals.
Tender, coal capacity	8 tons
Extreme width	10 ft.
Extreme height above rail	14 ft. 9 in.

The Boiler.

The boiler pressure is 190 pounds. The firebox is of the Belpaire type, with straight side sheets, unusually wide water spaces and relatively long staybolts. The water spaces are 4½ inches all around at the mud ring. The taper sheet of the boiler is in front and the rest of the shell is straight back to the firebox, the outside firebox sheet tapers toward the rear to save weight at the back and to give more room in the cab. (The firebox crown sheet is inclined so that it can not be entirely uncovered at any moment and the outer sheet is made parallel to it for obvious reasons). The tubes, 194 in number, are 2¼ inches in diameter and 16 feet 1 inch long. They are long because it was necessary to get the driving wheels between the cylinders and the front of the firebox. If the back tube sheet was of the usual form and the front tube sheet in its usual location, they would be about 15 inches longer. The front tube sheet is set back about 10 inches into the shell and the back tube sheet is

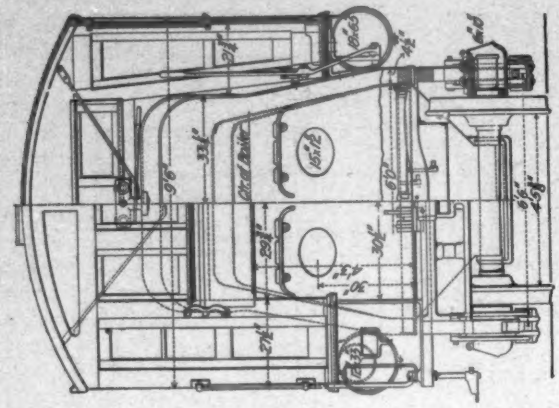


Fig. 3.

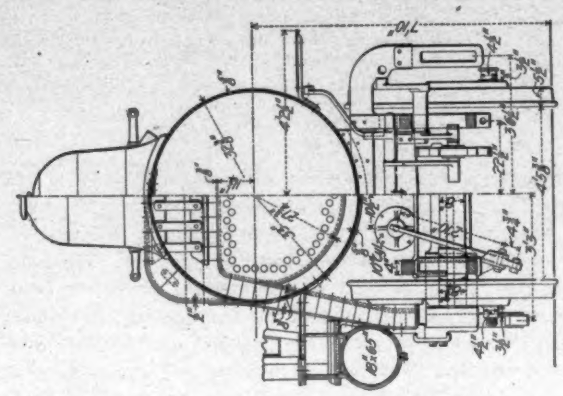


Fig. 4.

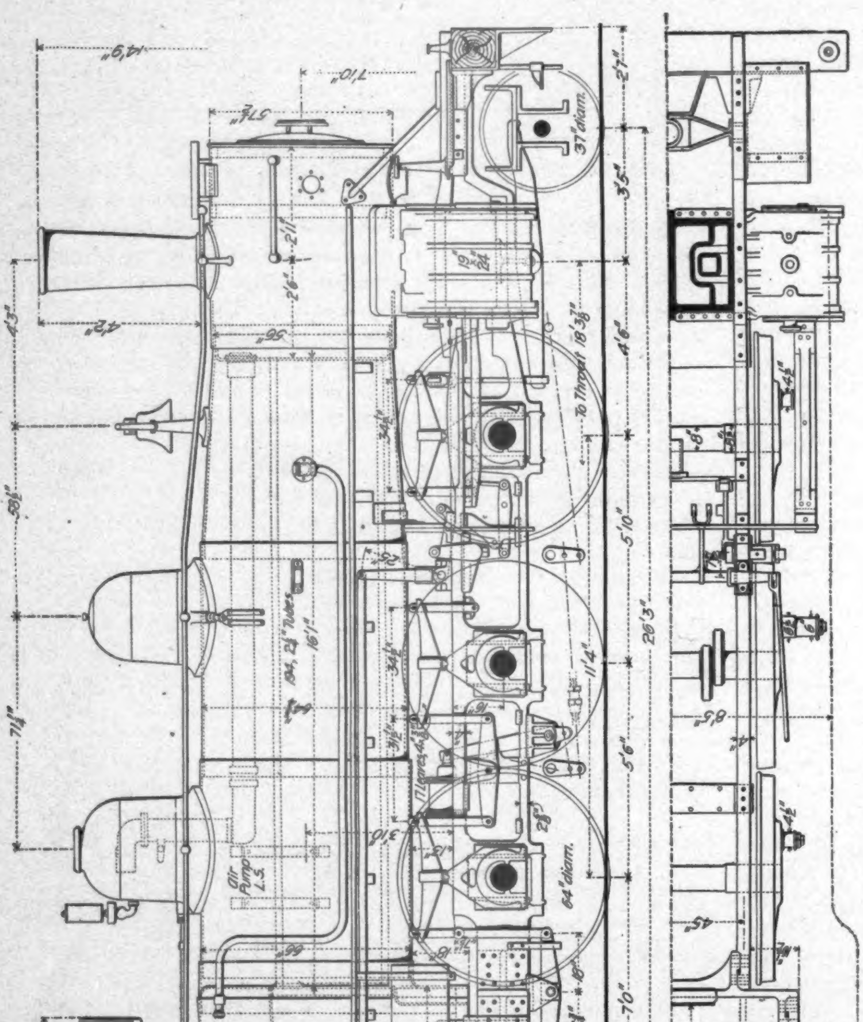


Fig. 1.

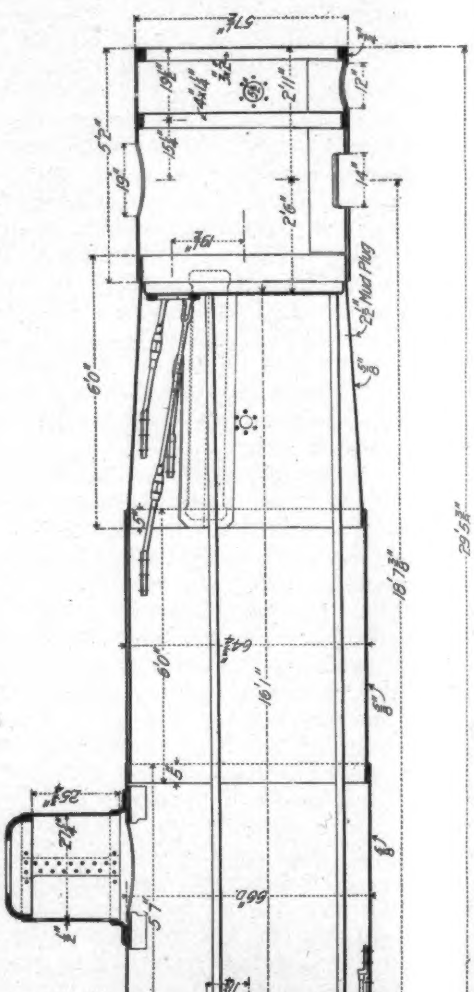
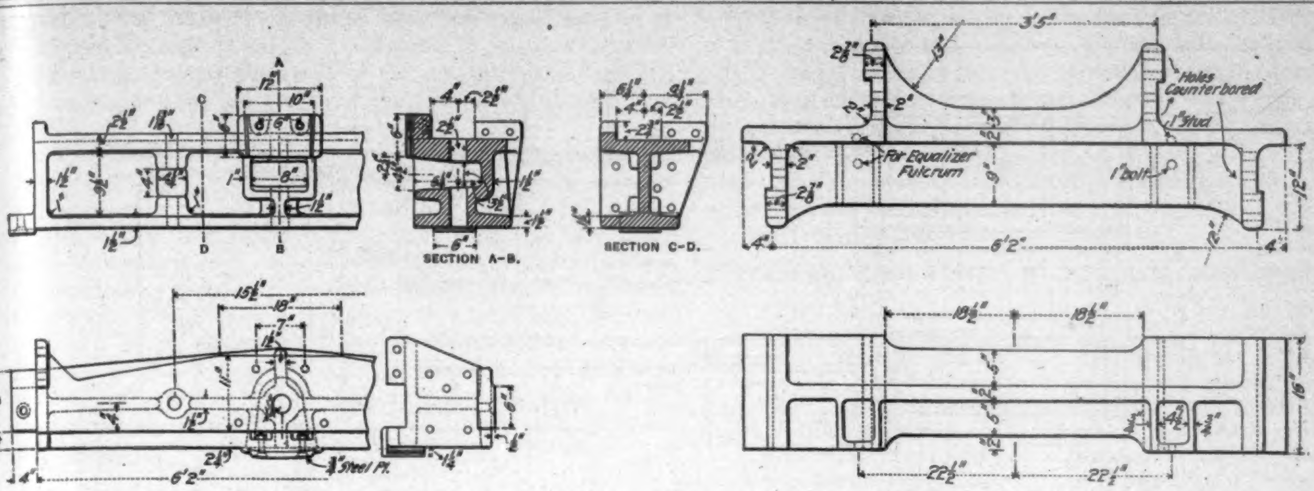


Fig. 2.
"Prairie" Type Locomotive.—C. B. & Q. R. R.



Cross-Bar at Rear Ends of Frames.

Cross-Bar in Front of Firebox.

Fig. 5

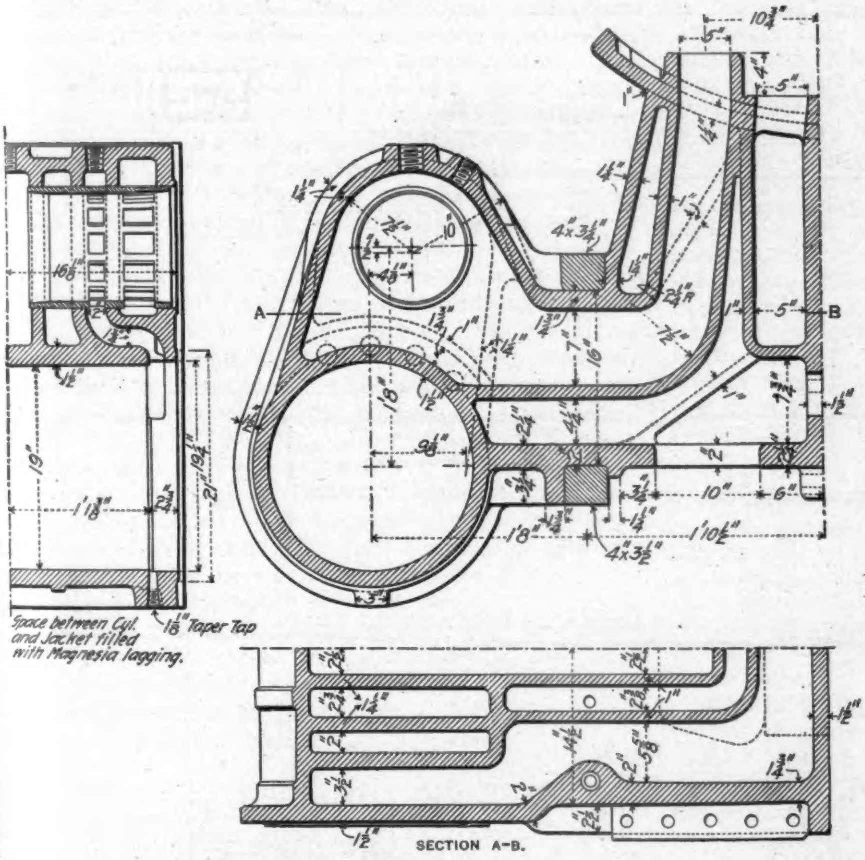


Fig. 6.

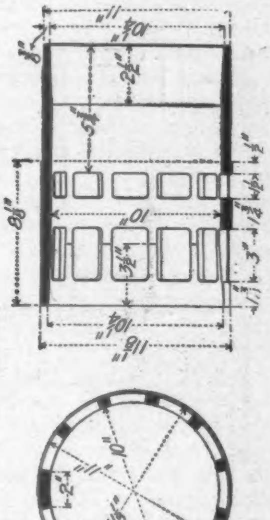


Fig. 7A.

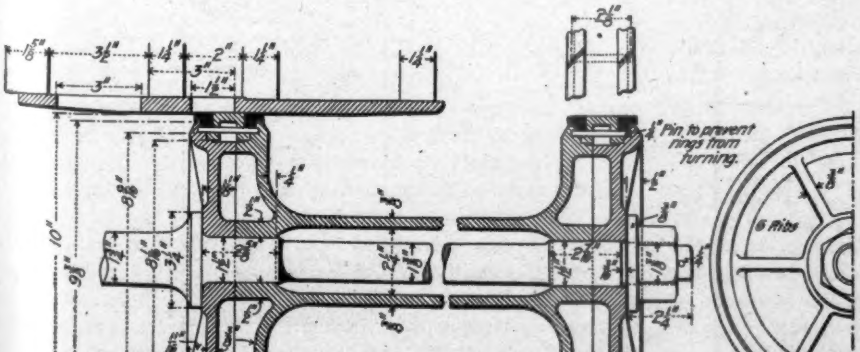


Fig. 7.

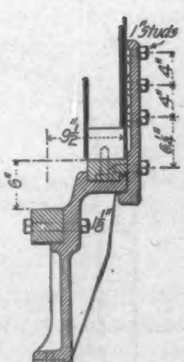


Fig. 10.

"Prairie" Type Locomotive—C. B. & Q. R. R.

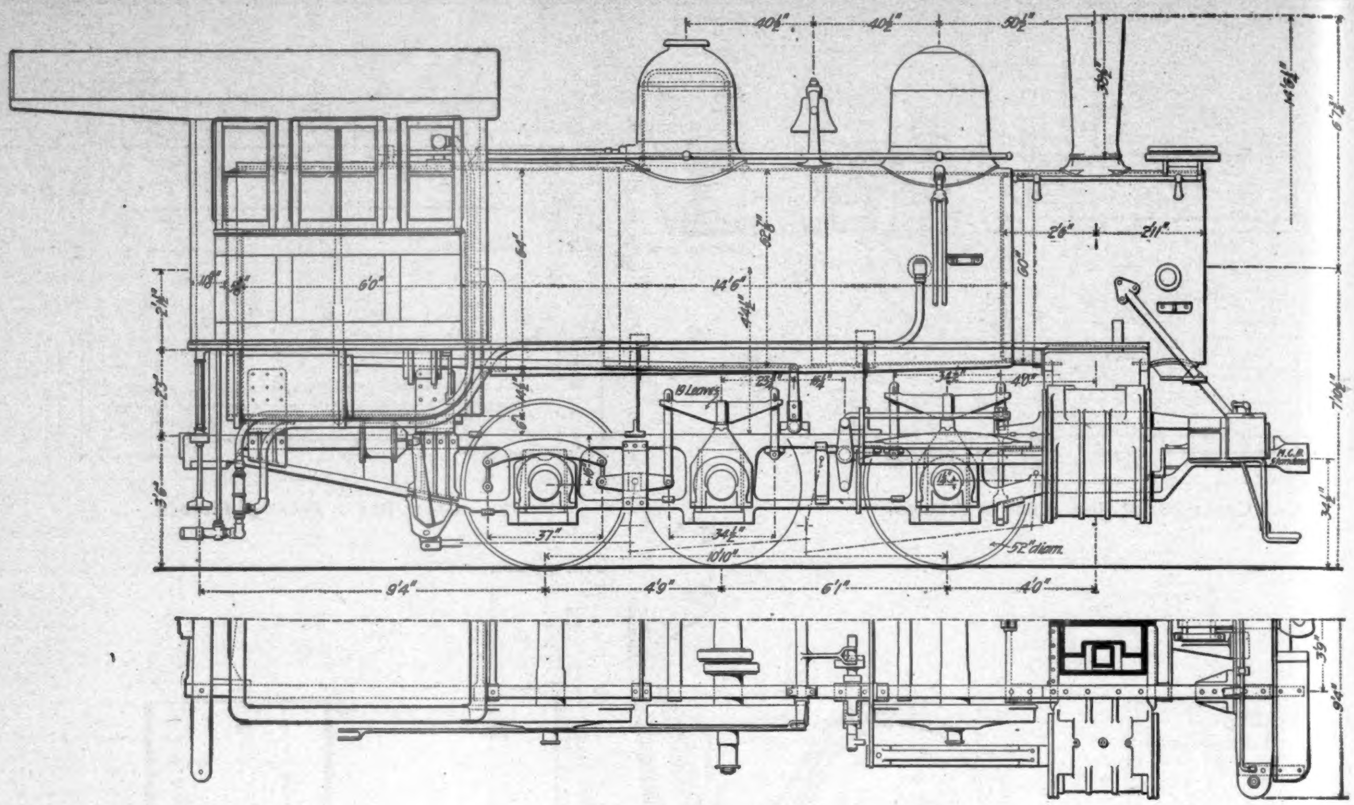


Fig. 8.

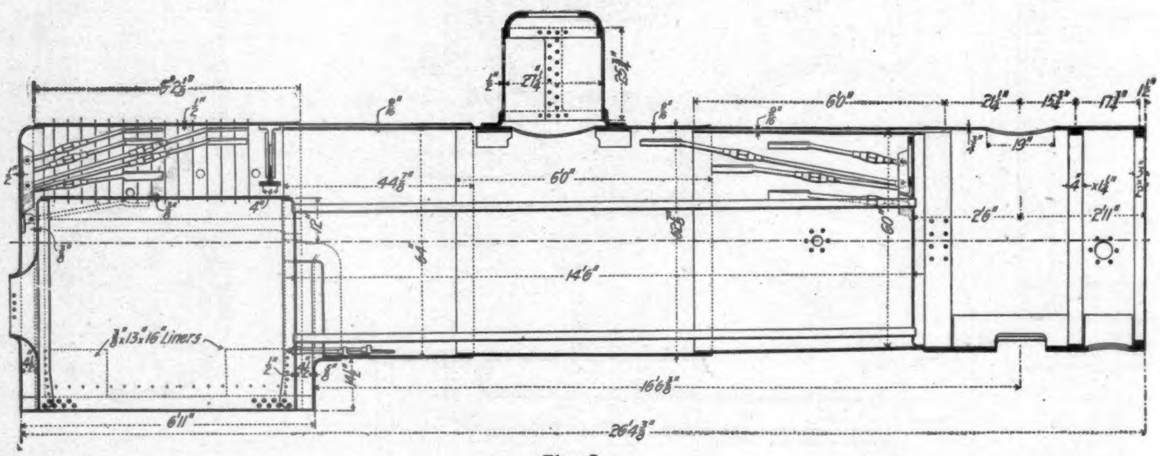
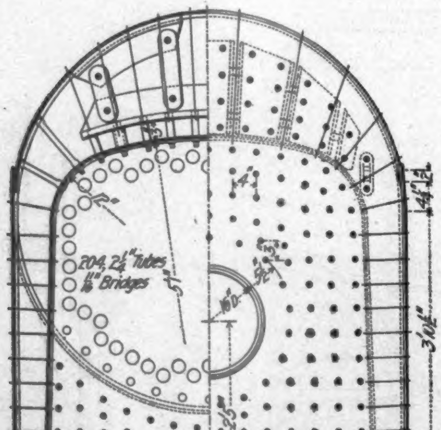


Fig. 9.



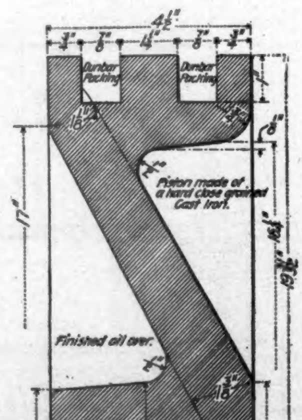


Fig. 9A.

Fig. 11.

Wide Firebox Switching Locomotive.

Class "Q3" C. B. & Q. R. R.

dished. This construction of the back tube sheet renders it comparatively easy to put in a new one. It removes the tube ends slightly beyond the reach of the radiant heat of the fire and adds a trifle to the length of the combustion space in the firebox.

The sectional view of the boiler shows turnbuckles in the diagonal braces. These soon become incrusted with scale in service, so as to be fast and rigid, but they are used in order to provide a close adjustment in the braces when the boilers are new. The throat stays are put in on the staybolt principle, for the purpose of obtaining a uniform distribution of the loads upon them. The firebox is provided with a brick arch, with an improved system of air ducts, in order to improve the combustion and reduce the smoke. Another feature of the firebox is the two fire doors. The clear opening into the water leg of the firebox at the throat sheet is worthy of note as being unusual.

Details of Construction.

The cylinder is illustrated in Fig. 6, and the valve in Fig. 7. The valves are upon the tops of the cylinder and the frames are double at the cylinders. The valves have internal admission and they are made solid. The packing is of the bull ring type, with small packing rings of angle section. The valve bushings have one bridge 2 inches wide which is placed at the bottom when in place. The joints in the packing bear upon this bridge, and there is no possibility of catching the ends in the ports. The other bridges are ⅝ inch wide. The Class R engines have 1 inch lap, 1/16 inch clearance and 6 inch valve travel, but the design of the valve makes any change in the lap or clearance a very simple matter.

The cross-head is the Lair type, with cast-iron top guide and a steel bottom guide. The shoes are cast iron babbitted. The pistons are cast iron, with Dunbar packing. The engine has phosphor-bronze bearings throughout. The driving axles have 8½ by 9½-inch journals, and wheel seats enlarged to 8¾ inches. The key ways are cut with a 5⅜-inch diameter milling cutter.

The air-brake cylinders are located in front of the rear driving axle, and between the frames, as shown in Figs. 1 and 4. The leading truck has a swing center and 37-inch wheels. The tender has a 5,000-gallon tank and capacity for eight tons of coal. It is carried on two four-wheel trucks.

Wide Firebox Switch Engine.

Another new design by the same road is that of the Class G 3 six-coupled switch engine, with a wide firebox and piston valves. Four of these are now building at the Aurora shops. Their chief dimensions are as follows:

Six-wheel Wide Firebox Switcher.
C. B. & Q. R. R.

Gauge of track	4 ft. 8½ in.
Cylinders	20 by 24 in.
Driving wheel centers	44 in.
Thickness of tires	4 in.
Wheel base, engine and tender	38 ft. 9 in.
Driving wheel base	10 ft. 10 in.
Firebox, inside	57¼ by 72 in.
Boiler, front end of shell	60 in.
Boiler at throat sheet	64 in.
Weight in working order (estimated)	122,000 lbs.
Weight of tender in working order (estimated)	72,000 lbs.
Capacity of tank	3,900 gals.
Capacity for coal	6 tons

This boiler differs from the one previously described. It has radial stays and is straight on top. The form of the firebox resembles that of stationary boilers of the locomotive type. There are 204 tubes, 2¼ inches in diameter and 14 feet 6 inches long. The water legs are 4½ inches wide at the bottom, and the staybolts begin to lengthen immediately above the mud ring. The turnbuckle adjustment for the braces is used in this boiler also. The method of supporting the boiler is shown in Fig. 10. This is in the form of a bracket reaching out from the frames and receiving the weight directly from the mud ring by a shoe. The side thrust is taken by a groove in the bracket, and the pad merely holds the boiler down when swayed. This appears to be an excellent boiler support. In this case a heavy bracket is necessary on account of the excess of width of the firebox over the frames.

Wide firebox switch engines have been in use for a number of years, but this is believed to be the first built for soft coal. The principal merits in this type of boiler which the designers claim is simplicity of construction, a boiler which will prove inexpensive to maintain, and lastly a very large heating and grate surface for a 6-wheel switching engine. The principal object was to overcome the difficulty with smoke in the peculiarly trying service of switching.

PRIZE FOR HIGH SPEED ELECTRIC RAILROAD PLAN.

The German Society of Mechanical Engineers will this year award the Veitmeyer prize of 1,200 marks with gold medal for the best plan and specifications for an electric railroad between two distant cities, designed exclusively for trains running at a speed of 200 kilometers (124¼ miles) per hour, and following each other in quick succession without intermediate stopping points, each train to have a minimum capacity of 150 passengers. The stipulations are given in full in the January number of Glaser's Annalen, and the contest will close on October 6th this year. The prize will be awarded at the November meeting of the society. Concerning the subject selected, Mr. Wichert, one of the prize judges and a leading German Government engineer, writes as follows:

"The problem has a special interest at the present time, as the new century now dawning may see its practical solution. The construction of railroads specially designed for light trains of high frequency and enormous speed has so far received only passing attention. Look at it as you will, it is in line with the progress of the times, but whether a practical solution is possible or not, time, study and experiments alone can demonstrate. The subject requires that careful consideration be given to the design of terminals with the necessary installation for handling trains of 200 kilometers' speed without risk or confusion. As such speeds have never yet been attained, the problem may bring out the impossibilities, if any, which stand in the way of solving it. No definite distances being laid down, the solution will not give absolute, but only relative quantities. Correct theories ought to be developed in regard to the resistance at high speeds, which in the United States have already reached 150 kilometers per hour. The problem must therefore be based on an unprejudiced review of the literature and the material at hand relating to such matters as train and air resistance, brake action, etc., referred to high speeds, and the committee having the subject in charge thinks that there is still a wide field unexplored in that direction."

Washing locomotive boilers with cold water has been considered by many as injurious to the sheets because of the sudden contraction which it causes. Mr. Edward Grafstrom, writing in the "Railway Master Mechanic," defends the practice as a result of experiments which he has made with pieces of steel cut from boiler plate. These showed no deterioration after a large number of repetitions of heating to a temperature of 260 degrees and cooling with cold water. The advocates of the use of cold water hold that there are no initial stresses in the boiler when it is cold and that the effect of the cold water is to relieve the stresses which were caused by firing up. Mr. Grafstrom does not wish to be understood as saying that local cooling is not injurious, but advocates the uniform application of cold water to promote uniform contraction.

A most interesting development of the fire tube boiler rivaling water tube boiler capacity is promised by a paragraph in a recent editorial in "The Engineer" on the subject of marine boilers, quoted as follows: "It would be premature to say much, but experiments have been carried out recently under our own eyes, with a fire tube boiler, with the result that it very readily produced its own weight of dry steam per hour; that it made nearly eight pounds of steam per pound of coal burned and that every portion of the boiler is accessible for repair, almost without removing a nut."

Mogul Freight Locomotive—New York Central R. R.

A. M. WAITT, *Superintendent Motive Power and Rolling Stock.* SCHENECTADY LOCOMOTIVE WORKS, *Builders.*

MOGUL FREIGHT LOCOMOTIVES.

New York Central & Hudson River R. R.

The Schenectady Locomotive Works have just delivered to the New York Central a number of heavy mogul freight locomotives, one of which is illustrated by the accompanying engraving. In cylinder power, size of driving wheels, grate area and in general appearance these engines strongly resemble those of the same type furnished in 1898 by the same builders and illustrated on page 363 of our November number of that year. In boiler power and weight, however, the new design far surpasses the earlier one, and as the 1898 engines have done most satisfactory work the greater power of the present design may be expected to improve upon that proportionately. The comparison in weight and boiler capacity shows progress as follows:

	1898.	1900.
Total weight, lbs	142,200	155,200
Weight on drivers, lbs	123,000	135,500
Heating surface, sq. ft	2,111	2,507
Water capacity of tender, gals	4,500	5,000

The design and specifications were furnished by the mechanical department of the road and were worked out under the direct supervision of Mr. A. M. Waitt, Superintendent of Motive Power. The details of the engines are changed from the earlier design in the use of Fox pressed steel tender trucks, cast iron taper stacks, wooden pilots and the "H" crosshead instead of the Laird. This engine has an admirable arrangement of hand holds on the engine and tender, with steps at both ends of the tender. The brake shoes are back of the driving wheels and the driver brake cylinder is under the boiler barrel instead of at the rear ends of the frames. The driving journals are 9 by 12 in. and the truck journals 6¼ by 10 in. Other characteristics of the design are included in the following table:

General Dimensions.

Gauge	4 ft. 8½ in.
Fuel	Bituminous coal
Weight in working order	155,200 lbs.
Weight on drivers	135,500 lbs.
Wheel base, driving	15 ft. 2 in.
Wheel base, rigid	15 ft. 2 in.
Wheel base, total	23 ft. 3 in.

Cylinders.

Diameter of cylinders	20 in.
Stroke of piston	28 in.
Horizontal thickness of piston	4½ in. and 5 in.
Diameter of piston rod	3⅜ in.
Kind of piston packing	Cast-iron rings
Kind of piston rod packing	U. S. metallic
Size of steam ports	18 in. by 1¼ in.
Size of exhaust ports	18 in. by 2¾ in.
Size of bridges	1⅛ in.

Valves.

Kind of slide valves	Richardson balanced
Greatest travel of slide valves	5½ in.
Outside lap of slide valves	⅞ in.
Inside lap of slide valves	Clearance 1/128 in.
Lead of valves in full gear	1/32 in. negative lead full gear forward, 3/32 in. negative lead full gear back

Wheels, Etc.

Diameter of driving wheels outside of tire	57 in.
Material of driving wheel centers	Cast steel
Driving box material	Gun metal
Diameter and length of driving journals	9 in. dia. by 12 in.
Diameter and length of main crank pin journals (main side 6¾ in. by 5¼ in.)	6 in. dia. by 6 in.
Diameter and length of side rod crank pin journals	Back 5 in. by 3¾ in., front 5 in. dia. by 3⅝ in.
Engine truck, kind	2-wheel swing bolster
Engine truck journals	6¼ in. dia. by 10 in.
Diameter of engine truck wheels	30 in.

Boiler.

Style	Extended wagon top
Outside diameter of first ring	67 5/16 in.
Working pressure	190 lbs.
Material of barrel and outside of firebox	Carbon steel
Thickness of plates in barrel and outside of firebox	21/32 in., ¾ in., ½ in. and 11/16 in
Firebox, length	108 1/16 in.
Firebox, width	40⅜ in.
Firebox, depth	F. 82 21/32 in., B. 70 21/32 in.
Firebox, material	Carbon steel
Firebox plates, thickness	Sides 5/16 in., back ⅜ in., crown ⅜ in., tube sheet 9/16 in.
Firebox, water space	Front 4 in., sides 3½ in., back 3½ in.
Firebox, crown staying	Radial stays, 1⅛ in. dia.
Firebox, staybolts	Taylor iron, 1 in. dia.
Tubes, material	Charcoal iron, No. 11
Tubes, number of	366
Tubes, diameter	2 in.
Tubes, length over tube sheets	12 ft. 2½ in.
Fire brick, supported on	Studs
Heating surface, tubes	2,321.6 sq. ft.
Heating surface, firebox	185.6 sq. ft.
Heating surface, total	2,507.2 sq. ft.
Grate surface	30.3 sq. ft.
Ash pan, style	Sectional dampers F. and B.
Exhaust pipes	Single
Exhaust nozzles	5 in., 5¼ in. and 5½ in. dia.
Smoke stack, inside diameter	16 in. at choke, 18½ in. at top
Smoke stack, top above rail	14 ft. 6½ in.
Boiler supplied by	2 Monitor injectors, No. 10

Tender.

Weight, empty	44,700 lbs.
Wheels, number of	8
Wheels, diameter	33 in.
Journals, diameter and length	5 in. dia. by 9 in.
Wheel base	16 ft. 6½ in.
Tender frame	10-in. channel iron
Tender trucks	Two 4-wheel Fox pressed steel floating bolster type
Water capacity	5,000 U. S. gallons
Coal capacity	10 tons
Total wheel base of engine and tender	50 ft. 8 in.
Brakes	Westinghouse-American combined, on drivers, tender and for train

The boiler covering is the Franklin sectional, the brakes are the Westinghouse, and the other special equipment includes Leach sanders, National Hollow brake beams, Gould couplers, Nathan & Co.'s 1899 type lubricators, and the tenders are equipped with water scoops.

CHICAGO & NORTHWESTERN SHOPS AT CHICAGO.*

Extensive Improvements.

II.

Buildings.

The new buildings for these extensions were designed by Messrs. Frost and Granger of Chicago, and while artistic effect is not expected in railroad shops, considerable attention has been paid to their appearance, without, however, involving extravagance. The power house is the best example of this, and it is entirely appropriate. The requirements were first decided upon by the motive power officers. Then the detailed arrangements were settled, and the architects were called upon to do that which they are best able to do—design and erect the buildings. It is not unusual in cases of this kind, and especially in new shop plants, for the buildings to be designed and built by other departments, the arrangement of the interiors being left for the mechanical department to fix afterward. Such a method is never satisfactory. It results in good buildings, but they are not always convenient for those who use them.

The buildings are of brick, with steel frame roofs, that of the power house being covered with tile arches and concrete, while the others are slated. The foundations have concrete footings with stone caps. The steel work was done by the Kenwood Bridge Company, the mason work by C. W. Gindle, the cranes were furnished by Pawling & Harnishfeger of Milwaukee. Special attention was given to light and ventilation. The water closets and wash rooms for the men have been well arranged. The wash rooms have clothes lockers for the men, and the urinals and closets are placed in separate rooms. It is not necessary to show these in detail in the various shops, but it is worthy of record that good facilities of this kind, including clothes lockers and shower baths, are now considered necessary. The improvements extend these in the old shops as well as in the new.

The shops will be heated by exhaust steam from the power house, and when this is not sufficient, direct steam from the boilers will be used in addition. The intention is to concentrate the steam plant in the power house, and only such steam as is needed for heating will be taken from that building. The heating pipes are run overhead and the waste returns underground. The lighting will be by electricity throughout.

The Power House.

This building, Fig. 1, is 100 by 112 feet, and 30 feet in the clear, under the roof trusses. The basement is 9 feet 8 inches deep under the machinery room. The main walls are 25 inches thick, the roof is supported on five modified Howe trusses, the construction of which may be seen in the drawing of this detail, Fig. 2. The purlins are 9-inch 21-pound I beams, and are bolted to the trusses. The arches are 6-inch segmental tiles, with concrete filling, and composition roof covering. The roof was designed for a permanent and snow load of 100 pounds per square foot. The boiler room is 46 feet wide and the machinery room 54 feet, with a brick wall between. The roof trusses meet upon this dividing wall and on the machinery room side, it also carries an 18-inch 55-pound I beam girder for the crane support, the other support being built into the opposite main wall. The elevation of this building shows its substantial appearance and the inclined buttresses at the corners. This building has a 5-inch concrete floor, laid upon 8, 9, 10 and 12-inch I beams and brick arches. There are four 17 by 12-foot skylights in the roof, two over the boiler room, and two over the machinery room. Those over the boiler room have 30-inch and the others have 12-inch Globe ventilators. The chimney is of brick and 180 feet high. The boiler room provides for six 250-horse-power Babcock & Wilcox water-tube boilers, arranged in three batteries of two in each setting, giving at present a total of 1,500 horse power, with space for increasing this to 2,000 horse power when extended. We shall describe the boiler plant in detail in a future issue. Its arrangement is excellent. The brick chimney was decided upon after a careful consideration of mechanical draft. The original plan contemplated using three 66-inch iron stacks 107 feet high, with fans and motors, but when the cost of operation and maintenance of this system was considered it was discarded in favor of a substantial brick chimney. The reasons for this will be given more completely in connection with the description of the power questions, which will require an article by themselves. It is sufficient now to say that the chimney was found to be much cheaper than mechanical draft. There was practically no difference in first cost, while the operation of mechanical draft would be a constant annual charge. The boilers are equipped with automatic stokers, and the coal is handled entirely by machinery. It is stored in elevated bins, from which it runs by gravity to the boiler fronts. This will undoubtedly be an exceedingly economical plant in operation and in maintenance. Boilers of this type are remarkably economical in repairs.

The Boiler Shop.

This building, Figs. 3 to 6, is 120 by 300 feet, the width being the same as that of the main machine shop. The boiler shop has 14 transverse tracks connecting with the long transfer table, which also serves the locomotive shop, and over these tracks a 50-ton electric crane, with a 67-foot span, travels the entire length of the shop. At the north end of the building is the riveting tower, of which we show a section at the left of Fig. 4. The riveting and hoisting machinery for this riveting tower was described in our issue of June, 1897, page 195. It was in use in the old boiler shop. The riveter has a gap of 12 feet and works with hydraulic pressure of 1,500 pounds per square inch, so controlled as to give pressures of 25, 50 or 75 tons, as required on the work. The tower crane has a capacity of 40,000 pounds and a lift of 49 feet 3 inches. The longitudinal traverse of the tower crane is 24 feet.

This building consists of a main portion 67 feet wide by 40 feet high, and a wing 49 feet wide and 22 feet high. The wing has a traveling crane of 5 tons capacity running over its entire length, and the machinery is arranged with this in view. The cranes in both portions of the buildings are supported upon independent columns, as indicated in Fig. 6. The main walls of this building are 25 inches thick, the lighter side walls being 17 inches thick. The main roof is supported on trusses of the Fink type, shown in Fig. 6, which also shows details of the foundations. The machinery in this building is shown in a general way in Fig. 4. The crane service in this shop is admirable. The track arrangements are also good. A standard-gauge track runs through the shop lengthwise, and another across it at right angles, connecting to the transfer table. The wash room is entered from the wing of the building, and it contains 24 wash bowls, 150 lockers and two shower baths. Adjoining it are 12 closets and 14 urinals.

The Tank Shop.

The repair work on tenders has been more carefully considered in this case than is usual. A length of 144 feet has been added to the old shop, making the total length 344 feet. This shop is shown in Fig. 7. Its clear width between pilasters is 74 feet 8 inches, and it has a 30-ton traveling crane with a span of 72 feet 5 inches and a lift of 16 feet 10 inches. The walls of the new shop are 24 feet 7½ inches in height, and the walls of the old building have been raised to that height. The highest tender tank on the road is 11 feet ¼ inch over all when standing on the rails. The machinery in this shop is placed near the walls and out of the way of the cranes.

There are tracks for receiving nine tenders at a time. When they enter the shop, the tanks are lifted off by the crane and the frames, with the trucks, are moved over to the other side of the building. The truck erecting shop, with space for 20 trucks, is at the end of the building, opposite that containing the long tracks. The doors of the building are 10 feet wide by

*For the previous article on the general plan of these improvements see page 82.

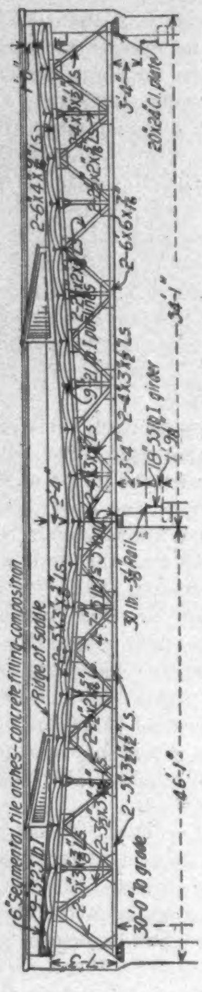


Fig. 2.—Roof Truss of Power House.

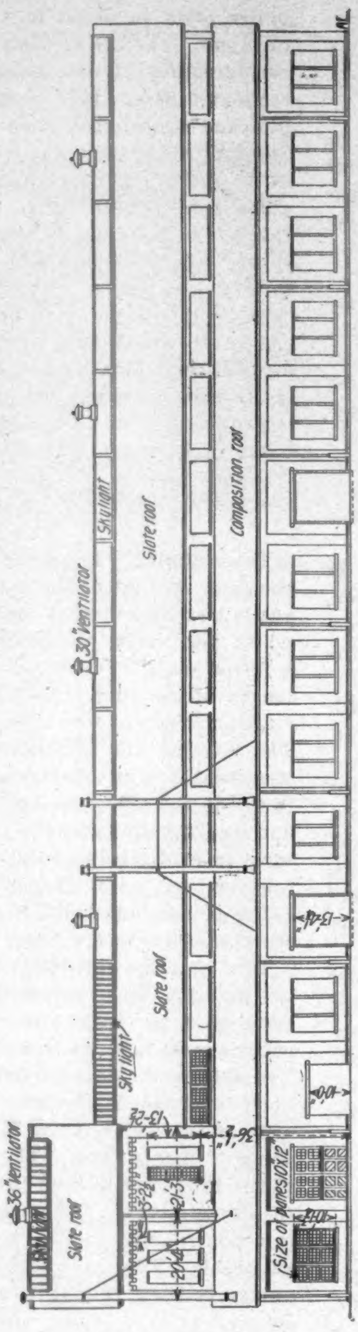


Fig. 3.—Boiler Shop—Side Elevation Showing Riveting Tower.

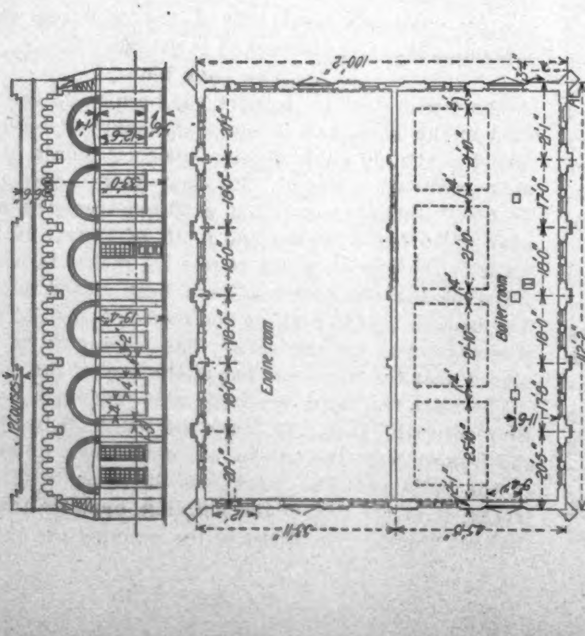


Fig. 1.—Plan and Elevation of Power House.

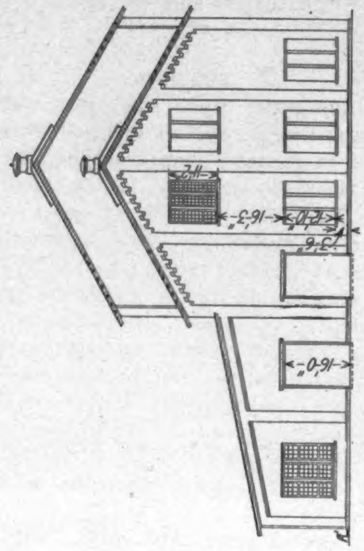


Fig. 5.—Boiler Shop—South End Elevation.

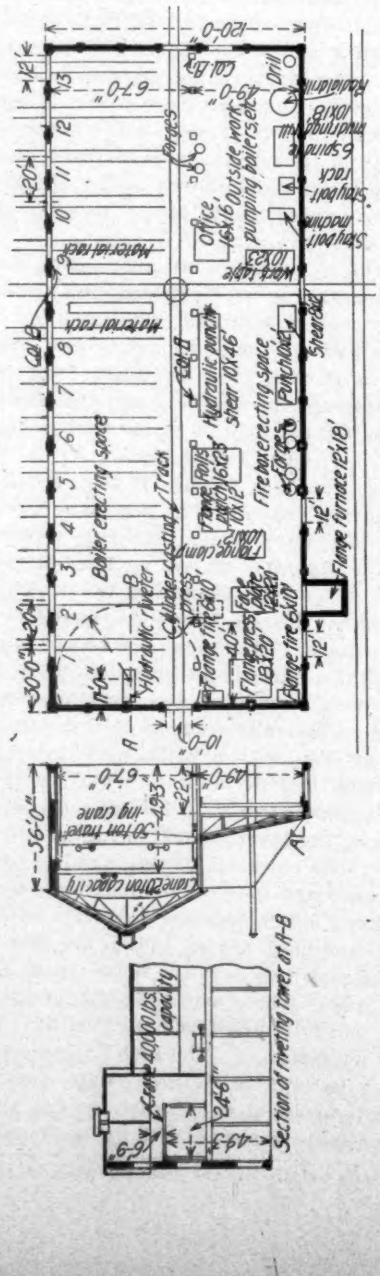


Fig. 4.—Plan and Sections of Boiler Shop.

CHICAGO AND NORTHWESTERN SHOPS AT CHICAGO.

Extensive Improvements.

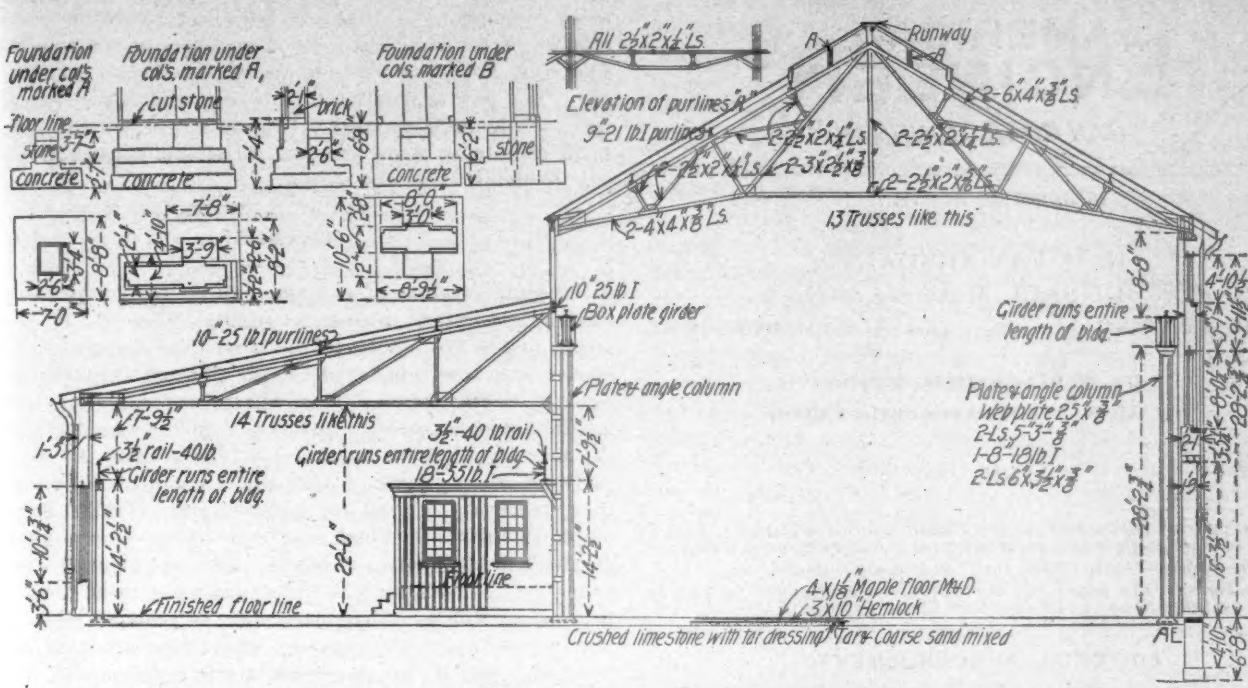


Fig. 6.–Boiler Shop–Section of Roof and Crane Columns Showing Foundations which are Located in Fig. 4.

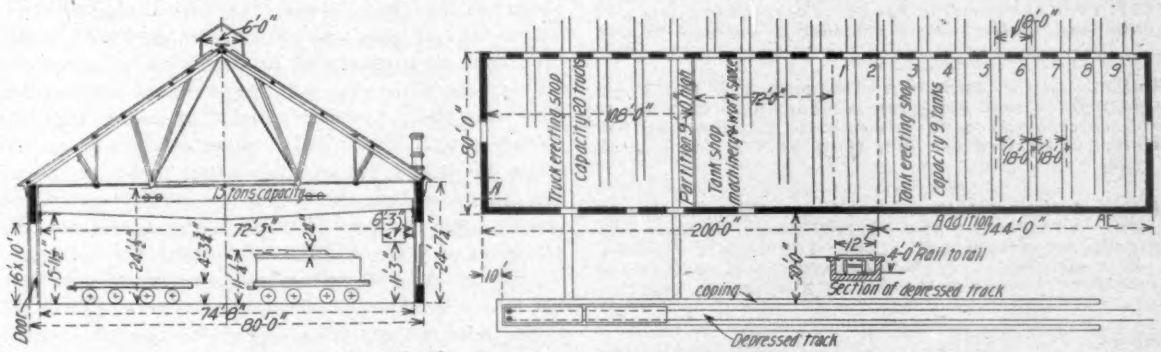


Fig. 7.–Tank Shop–Plan and Section.

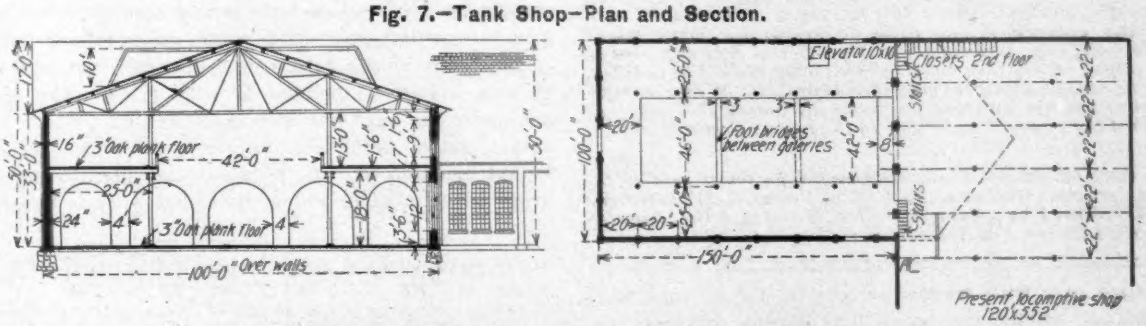


Fig. 8.–Machine Shop–Annex Plan and Sections.

CHICAGO AND NORTHWESTERN SHOPS AT CHICAGO.

Extensive Improvements.

16 feet high. On one side of the building is the transfer table, and on the other, running its full length, is a track depressed 4 feet below the surrounding ground. This is for unloading wheels, and it is placed 50 feet from the shop, which gives a large amount of room for storage. The walls of this building are 18 inches thick. It has five ventilators 12 feet long by 6 feet wide. Adjoining this shop is a 33 by 24-foot building containing the wash room, with 20 wash bowls and 150 lockers, and, in a separate room, 10 closets and 9 urinals.

The Machine Shop Annex.

Such work as turning up crank pins, making new parts of engines, brass work, bolts and rods, usually interferes seriously with the heavier work of a shop, and by being scattered all about it is a source of expense and annoyance, which will be entirely done away with in these shops by concentrating it all in this machine shop annex, a building 100 by 150 feet, as shown in Fig. 8. This is a two-story building adjoining the machine shop. The upper floor is in the form of a gallery, 25 feet wide on the side and 20 feet at the end. There are two 3-foot bridges and an 8-foot passage across. The lower story is 18 feet 6 inches high in the clear, and the upper one 13 feet. The opening in the floor is 42 by 132 feet. The walls for the lower story are 24 inches thick and those for the second story are 16 inches. A 10 by 10-foot elevator of 5,000 pounds capacity is provided in this shop. There are nine skylights, 10 feet high at the ends and 20 feet long on the ridges. The end door is 16 by 12 feet, sufficient for taking a box car into the building. The floors are of 3-inch oak plank. All piers and foundations are built on concrete.

We shall present the power plant, and information concerning the electrical distribution, in our next article on this subject.

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At one time cars with frames of commercial sections were very prominent among the promising designs for large capacity, but of late comparatively few have appeared. This seems strange in view of the strong inclination in several quarters to prefer wood to steel for flooring and siding, particularly in cars which are to be used for coal traffic. In this issue we print a description of an interesting steel frame coal car, which is not only attractive in appearance but is worthy of study from a structural standpoint. This car was designed under the direction of Mr. W. H. Lewis, Superintendent of Motive Power of the Norfolk & Western, by Mr. C. A. Seley, Mechanical Engineer of that road, and it is illustrated fully in this number. This car is a high-sided coal gondola, with a nominal capacity of 80,000 pounds. It has a steel frame, with wooden floor and sides and drop doors. With two heavy trucks designed for cars of 100,000 pounds capacity, weighing 15,500 pounds, this car weighs but 33,700 pounds, and with its own trucks, which will be much lighter, the weight will be reduced from that amount. The center sills are 15-inch channels and the side sills 8-inch channels. The stakes of the sides are arranged in the form of trusses, riveted to the side sills and to gusset plates at their upper ends. The upper row of rivets in these connections also take in the lower flanges of heavy angles which serve as compression members of the side trusses. The truss side frame is not a new idea in car construction, but it is a new application in this case, and it will be watched with considerable interest. This design shows the possibility of combining wood and steel in simple construction without involving excessive weight.

CRANES.

The concentration of engines, boilers, air compressors and electric generators into one building, whereby six separate steam plants are eliminated, is a striking feature of the improvements now being made at the Chicago shops of the Chicago & Northwestern. This will probably appear to many as the important accomplishment of this admirable work. Without the slightest intention of underrating the saving in fuel and in wages which this will accomplish, it is believed that the saving through the improved crane service in the new buildings will far outweigh that of the improvement in the production and distribution of power. Here is a plant in which the heavy boiler work for 1,185 locomotives is to be done. This boiler shop will be a busy place, and the economy of its operation, as well as its real capacity, will depend upon the promptness with which the heavy parts are handled and the men supplied with work. It will not do to make them wait. This shop was designed with a view of utilizing electric traveling cranes, and so also was the tank shop, which forms a part of the same plan, described in this issue. There is nothing at all remarkable in this fact except that it was not done at least five years ago. A sensible and substantial crane service is so seldom seen in a railroad shop as to make a case of this kind stand out boldly. It is strange that this is so, because no one can fail to see that the cost of locomotive repairs depends very largely upon the use of labor-saving appliances and the employment of every facility for keeping the men and machines constantly supplied with work and material. It is beyond belief that a mechanical officer of any large road in this country to-day does not appreciate crane service. It is entirely beyond comprehension why one of them put an elaborate drop pit in a new erecting shop and made no provision whatever for cranes even in the future, but this has just now been done. It was, moreover, pointed to with pride. The crane is undoubtedly the most valuable machine in a modern engineering establishment because it increases the output of every individual machine tool in the plant and adds to the capacity of every department in which the actual work is handled.

AN IMPORTANT STEP TOWARD WIDER FIREBOXES.

There are unmistakable signs of a turning toward wider fireboxes for bituminous coal-burning locomotives. For several years it has been apparent that the necessity for more grate area has been forced upon the leaders in locomotive improvement, and with this issue we are able to record an important practical step in this direction in two designs of wide firebox engines on the Burlington.

These fireboxes are not extremely wide, but that the mud ring has at last been deliberately spread beyond the limits of the frames of a soft coal-burning engine is cause for congratulation and commendation. The designs mentioned, and particularly the "Prairie type," are rather bold, and the arrangement of the frames will probably bring out some differences of opinion. This, however, is a mere detail which cannot adversely affect the general proposition that larger grates are necessary, and that they will be used. In this case the construction is strong and there is no reason to fear or expect other than satisfactory results. It is maintained that the firebox will be brought outside of the lines of the frames and various satisfactory ways will be found for accomplishing

it. It is not inconceivable that the frame construction at the firebox will be entirely revised. If it is necessary to keep the back ends of the frames out of the way of ash pans, on account of the desirability of depth in the firebox, it is possible to secure a decided advantage in construction by such a method as this of the Burlington Prairie type, with the addition of diagonal braces across the frames under the grates. The absence of the rigid bracing of the rear ends of the frames, formerly afforded by the heavy foot plates of earlier design, is making itself felt and the strong crossbar of the Prairie type, with some method of diagonal stiffening, should receive considerable thought as a possible relief from the troubles caused by the flexure of frames. It is believed that this construction can be made satisfactory even if it is not so in this design.

It is perhaps worth while to look into the supposed necessity for deep fireboxes. If they could be made shallow for bituminous coal burning on wide grates the wheel and long tube problems would be very much simpler, because the mud ring could be placed high enough to get moderate sized drivers under it.

In this connection it is well to consider the fact that bituminous coal is successfully burned in relatively small cylindrical furnaces in marine practice, which represent exceedingly shallow fireboxes. The rates of combustion are lower in marine service, but that which corresponds to the crown sheet is almost in the fire, it is so low. It is desirable to have plenty of combustion space, but it may, and probably will, be sufficient to put in into the form of length rather than depth. There is no difficulty in disposing of the driving wheels of the Columbia type without using excessively long tubes, but with six or eight wheels connected the case is different, unless the driving wheels are small.

In the Atlantic type, if the wheels are as large as those of the Baldwin engines on the Burlington, the tubes must be at least 16 ft. long. There is no apparently good objection to this when the diameter is correct. This length is necessary partly on account of large wheels and partly because of the four-wheel truck in front.

The Prairie type engine is regarded as an epoch-making design. Too much should not be expected of this individual case, but that it will show the possibilities and that it indicates the appreciation of a moderate widening of grates there can be no doubt.

SHOP TRACKS, LONGITUDINAL VS. TRANSVERSE.

The arrangement of tracks in locomotive erecting shops is almost the first question to arise in the plans for new shops or enlargements of old ones. We have inclined to the opinion in connection with large shops that where possible the tracks should be arranged lengthwise of the building, for reasons with which our readers are familiar, but in order to avoid onesidedness some arguments in favor of the lateral track plan were outlined last month. This has brought a ready response, printed elsewhere in this issue, from a superintendent of motive power who strongly favors the long tracks, and the support is so strong that it is commended to our readers. This gentleman emphasizes the importance of having two cranes in a shop anyway, for the benefit of their services in a variety of work, and he finds that the actual lifting and moving of locomotives occupies but about five per cent. of the working time of the cranes. When not used for this heavy work both cranes are available for other useful purposes which the single large crane, made necessary in the lateral plan, will not serve so well. The transfer table becomes a necessity with the lateral system, and it is considered as a serious obstacle to the handling of material to and from the erecting shop. Furthermore a transfer table cannot, like a crane, be used for assisting in the operations inside the shop. This argument is a strong one and it gives emphasis to the contention that the importance of satisfactory facilities for handling material and work in locomotive shops has been underestimated. Our correspondent points to the case of a large shop with the lateral arrangement requiring two transfer tables as an illustration of the inconvenience which they cause, and states that a shop with a transfer table upon each side is practically isolated from the surrounding buildings. At this time no case of this kind comes to mind, but the objection to two transfer tables is perfectly clear when expressed in this form. The advantage of easy supervision certainly rests with the longitudinal plan. It is believed to be exceedingly important to consider the comparative amount of general usefulness of cranes and transfer tables, both of which are expensive, in the settlement of this question. The size of the shop, the spans of the cranes, the amount of room which must be given up to the transfer table pit, all count in this connection, and it seems plain that there is a certain minimum size of plant to which the longitudinal tracks will not apply, but as the size and capacity of the shop increases the usefulness of the cranes increases, while for the same increase in size and capacity the disadvantages of the transfer table correspondingly increase.

Automatic stokers, as noted in these columns some time ago, have been tried in marine service on the Great Lakes in connection with Babcock & Wilcox water tube boilers on the steamer "Pennsylvania." This is believed to be the first installation of automatic stokers on shipboard, and the results of tests by Lieuts. B. C. Bryan and W. W. White, U. S. N., on the machinery of the ship, including the action of the stokers, are of great interest. They were published in the "Journal of the American Society of Naval Engineers" for August, 1899, and the record indicates that the stoker experiment was entirely successful. There was very little smoke, and practically none at all except when the fires were sliced and the clinkers removed. The saving in the wages of firemen and in improved combustion made possible by automatic stokers are important, and it appears to be possible and convenient to use them in connection with boilers of this type on shipboard. As the water tube boiler is making marked progress in this service it is possible that the use of automatic stokers may become equally common. In these tests it seems that the auxiliary engines for operating the stokers required but 1.68 per cent. of the total amount of steam used. It was demonstrated that the stokers could be stopped and the firing done by hand without difficulty. These stokers were made by the American Stoker Co. of Brooklyn, N. Y.

The most important facts concerning the breakage of staybolts brought to notice recently are the effects of the form of the firebox and the internal structure of the material of which staybolts are made. These were considered on page 382 of our December issue of last year and page 8 of the January issue of the current volume. In another column in the present issue Mr. R. Atkinson, of the Canadian Pacific, adds valuable support to the opinion previously referred to. In his experience it has proved advantageous to provide easy curves at the sides of the firebox and he has also found it necessary to consider the manner in which the iron is piled. That manufacturers will return to the box faggoting of 20 years ago is too much to expect. It is important that the effect of slab piling should be understood, however, and the makers should be urged to furnish iron that will be nearly equally strong in whatever direction it is bent. It is clearly impossible to place staybolts in the firebox so that they will always be bent most favorably and the proper course seems to be to select the irons which are known to be best qualified to stand the bending in any direction in which it may happen to come.

ELECTRIC POWER DISTRIBUTION.

Works of the Westinghouse Air Brake Company.

The electric distribution of power at the works of the Westinghouse Air Brake Co. at Wilmerding is an interesting installation because of its extent, its thoroughness, the use of steam turbines to drive the generators and specially because tests made before and after the change permit of knowing the advantages in economy of operation of the electric plant.

This is a case in which the saving of fuel is the largest saving because the character of the work done does not admit of the general use of individual motors, the majority of the machines requiring too little power to render this advantageous. The shafting, however, was speeded up and, therefore, a very important improvement is made upon the output of the machines. This plant is typical of a large class employing a great number of machines, and requiring but a small amount of power and located in a number of separate departments covering a large ground and floor area.

The shops were originally equipped with, for the time, an excellent system with a central boiler plant furnishing steam through underground steam pipes to 30 Westinghouse steam engines varying from 5 to 225 horse power and located in the various buildings with a view of reducing the belting to a minimum. It involved a large amount of steam piping, however. This plan was considered preferable to a smaller number of larger engines. It has always operated satisfactorily but the huge increase in the output of the works had very nearly reached the limit of the capacity of the boiler plant and this offered the desired opportunity for making the radical change which has been recently carried out. The manner of making the change itself is notable because the motors and turbo-generators were installed while the plant was running and without a minute's delay in the regular work of the shops. It was necessary merely to take off the engine belts and put on those for the motors and the change was made. The preliminary work was so thorough that it was not necessary to make a single change in the motors, the wiring or accessories after the electric system was put into operation. This means that the measurement of the power of the engines and the subdivision of the shafting for motor driving was done so well as to require no revision.

The plan shown in Fig. 1 serves to locate in a general way the factors in the system. For such a large establishment the arrangement is compact and of course if the buildings were separated by longer distances the saving in cost of operation would be greater. With about 4,000 linear feet of steam line the condensation to the engines amounted to 50 boiler horsepower, which was a constant loss. This is in spite of the fact that the piping was all well protected. This engraving shows the location of the engines by means of small circles made in black, and a glance shows what an amount of steam piping was involved. The new system places all the power and lighting generators in the power house and when in complete working order the single boiler plant and the three turbo-generators will furnish the light, heat and power for the entire establishment.

The boiler plant consists of two sections of Babcock & Wilcox boilers having 16 single boilers in all with a total capacity of 2,000 horse power. They are fed by Roney stokers and work under a pressure of 125 lbs. Run of mine coal is burned. The grate surface of each boiler is 25 square feet, the total for each half being 200 square feet, the heating surface of each boiler is 1,320 square feet or a total of 10,560 square feet. The ratio of grate area to heating surface is 52.8. No change is made in the boiler plant, which is arranged in two batteries of 8 single boilers each.

There were 30 engines in the shops located as shown in Fig. 1 and in the table below. The sizes and power of each are stated, the total nominal horse-power of the engines being 1,375. They were all operated without condensing.

NUMBERS, SIZES AND LOCATIONS OF ENGINES.

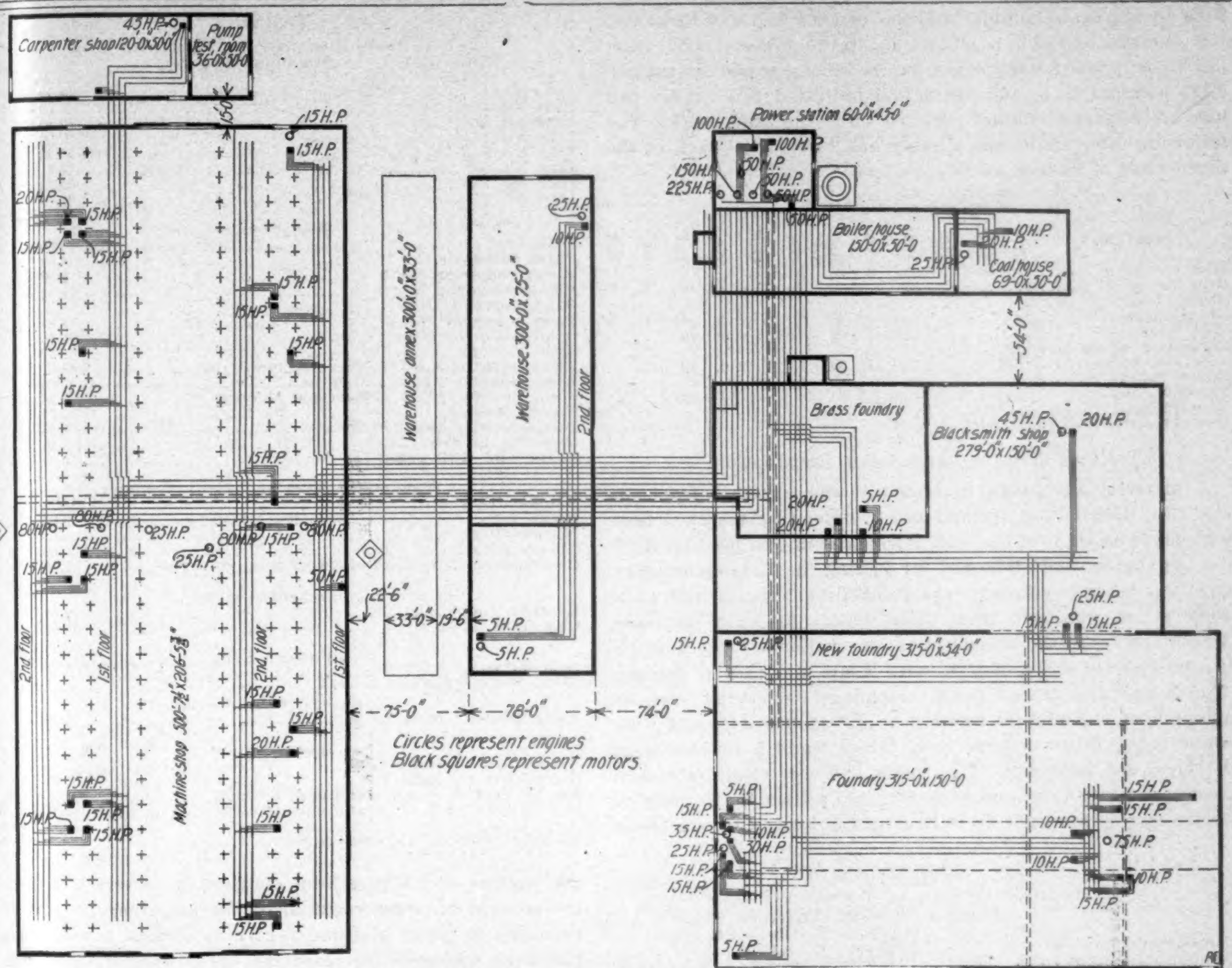
	Size.	Locations.	Purpose.	H.P.
Light Station.	16 and 27x16″	1st from entrance.	2,500 light machine.	225
	11 and 24x14″	2d " "	1,500 " "	150
	9 and 15x9″	3d " "	500 " "	50
	9 and 15x9″	4th " "	60 arc "	50
	12 and 15x9″	Centre of floor.	Generator.	50
Boiler House.	4½x4″	1st left from entrance.	Roney stokers.	5
	4½x4″	2d " "	" "	5
	4½x4″	3d " "	" "	5
	4½x4″	4th " "	" "	5
	5¼x5″	1st right from entrance.	Rotary water pump.	10
	9 and 15x9″	2d " "	Hot and cold air fan.	50
	7½x7″	Rear of boiler room.	Coal crusher.	25
Black-smith shop.	9½x9″	Boiler shop.	Boiler shop machinery.	45
	6½x6″	Rear of smith shop.	Buffer drop.	20
Iron Foundry.	7½x7″	Rear of smith shop.	Flask con. and sand elev.	25
	7½x7″	Left of entrance.	Rot. air pump and sand C.	25
	12x11″	Rear side.	Cleaning barrels.	75
	7½x7″	2d floor side.	Fan for blast.	25
	8½x8″	" " "	Flask and sand conve'rs.	35
Ex-per'l room.	4½x4″	Experimental Dept.	Experimental machine.	5
Pat-tern shop.	7½x7″	....	Pattern shop.	25
Car-pen't shop.	9½x9″	1st floor carpenter shop.	Carpenters' machine.	45
Machine shop.	11 and 19x11″	West side.	½ each A and C machine.	80
	11 and 19x11″	Next to fan.	½ " " "	80
	7½x7″	Fan.	Hot and cold air fan.	25
	7½x7″	"	" " "	25
	11 and 19x11″	Next to fan.	½ each B and H machine.	80
	11 and 19x11′	East side.	½ " " "	80
	9½x9″	Rotary pump departm t	Testing rotary pumps.	45
	4½x4″	Department B.	Night machinery.	5

The only steam engines which will remain permanently will be the two 10 h.p. exciter engines in the power station and those necessary to operate the stokers, air fan and rotary pump in the boiler house.

In the power station, of which several interior views were shown last month, are the three turbo-generators, two exciter units, the air pumps and condensers for the turbines and two Class D Ingersoll-Sergeant air compressors. These are arranged to belt from 100 h.p. motors. They have 18¼ and 11¼ by 14 inch cylinders with inter-coolers, and each has a capacity of 688 cubic feet of free air per minute. The arrangement of the machinery is indicated in Fig. 4. The generators are bipolar alternators running at 3,600 revolutions per minute. The armatures are designed especially for the high speed. The voltage from the large generators is 440 and that of the exciter units is 110 volts. The air pumps are driven by a 50 h.p. motor, belt connected. At the heaviest loads two of the turbine units are able to furnish all the power and also supply the lights; there is, therefore, a large margin in power under present conditions.

The wiring system is entirely underground and it follows in a general way the locations shown on Fig. 1. The switchboard in the power station has 9 panels. This was shown in Fig. 4 on page 67 of our March issue. The first, at the left, is the exciter panel, next are the three turbine panels; the meter panel, with ground detector, is next, and at the right are the four feeder panels. The first of these is for lights entirely. The second has the power circuits for the coal and boiler house, the first floor and east side of the machine shop. The third has the second floor of the machine shop and the west side of the first floor. The fourth has the blacksmith shop and foundry circuits. There are two sets of bus bars arranged to permit of connecting the generators to either. The lights may be taken from either bus bar, but the power can be taken from the upper one only.

The lighting system requires 2,500 incandescent and 60 arc lamps. The light circuits run in tunnels to transformers and



Electric Power Distribution.—Westinghouse Air Brake Works.
Fig. 1.—Plan of Buildings and Power System.

thence to the lamp circuits. The arc lamps are the Manhattan enclosed 110 volt 100 hour lamps. As the incandescent circuits carry 110 volts both kinds take current from the same circuits.

The motors are the Westinghouse induction type with no electric connection between the armatures and the circuits; they have no brushes. They are placed against posts, upon overhead timbers or in any convenient place, and beyond oiling them once a week they require very little attention.

Two independent 30 h.p. motors are used for running fans in the foundry and the others are mounted in different ways most suited to the requirements of each case. The motor drives in the machine shop are illustrated in Fig. 3. This is a two-story building, with line shafts running its entire length. In the lower story the motors are bracketed against the columns of the building where they do not occupy space that can possibly be needed. They are belted to counter shafts and thence to the line shafts in order to secure the desired speed of 112 revolutions per minute, which is an increase of 12 per cent. over the old arrangement. These motors run at a speed of 1,120 revolutions. In the second story the main shafts run at speeds of 172, 175 and 112 revolutions, and the motors are put overhead where they are entirely out of the way. The brass room line shaft runs at 172 revolutions and is belted direct to the motor without a countershaft. In the machine shop 23 sections of 3-inch shafting 15 ft. 6 in. long were dispensed with and in the blacksmith shop four sections. Four head shafts and 8 main countershafts were also saved in the machine shop by the use of motors.

The motors are started without the slightest difficulty. Near each motor is a controlling switch to which the four wires for each motor run. The smaller motors are started on the side circuits with 7/10 of the full voltage and when they are up to speed the whole voltage is used. This method is employed for motors up to 30 h.p. Auto-starters are used for the 50 h.p. motors and larger ones. The motors are run in multiple on the main circuits as indicated in Fig. 1, which shows the wiring. For testing street car air compressor motors in the machine shop a rotary converter is used. The alternating current is at 440 volts, and the direct current at 550 volts. The current for the rotary converter first passes through a two-phase regulator by means of which the direct current voltage can be varied at will from 440 to 625 volts.

The determination of the capacities of the motors was an important part of the work, which was particularly well done. In the machine shop the lines of shafting were 400 feet long and the engines drove them from the center of the shop. The measurement of power was done with indicators. First, cards were taken with one of the engines running all the machinery on one of the shafts complete. Shaft No. 1 in the machine shop required 58 indicated h.p., which was just the amount for four 15 h. p. motors. After averaging four indicator cards for the full load, the shaft was cut at the couplings (one section, estimated to require 15 h. p., at a time being cut off) and other cards taken as a check. In this way the proper location for each motor was found. Only one motor was changed after this careful work and that was on account of putting in additional machinery. The machine shop required one 50 h. p., two 20 h. p. and 24 15 h. p. motors, of which the locations for both floors are given in Fig. 1. The wires for the first and second floors are marked in the engraving and the corresponding motors are easily found. This diagram is intended to show the general plan of the wiring and motors on each circuit, but not to indicate the exact location. In all there are 57 motors

with an aggregate nominal capacity of 1,065 h. p. Of these two 100 h. p. and one 50 h. p. motors are in the power station, leaving 815 h. p. as the aggregate for the works proper, as against 1,375 nominal h. p. and 949 actual indicated h. p. under full load of the steam engines required to do the same work. The following table shows the number and capacity of each of the seven sizes of motors used:

Schedule of Motors.

Location.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.
Machine shop	1	50	..	..	2	20	24	15	..	..	..	..
Iron foundry	..	..	1	30	..	..	9	15	4	10	2	5
Brass foundry and blacksmith shop ..	..	..	..	..	3	20	..	..	1	10	1	5
Coal room	..	..	..	..	1	20	..	..	1	10	..	..
Carpenter shop and leather room	..	..	..	..	1	20	..	..	1	10	..	..
Boiler house	..	..	..	..	..	..	..	..	..	..	..	..
Pattern shop	..	..	..	..	..	..	..	..	1	10	..	..
Experimental room..	..	..	..	..	..	..	..	..	..	..	1	5
Power sta'tn 2-100 h.p.	1	50	..	..	..	..	..	..	..	..	..	..

Tests of Electrical and Steam Distribution.

A material advantage in economy was expected from the electrical distribution system, and in order to measure it tests were made on eight of the boilers which were first used for driving the engines and afterward for driving the turbo-generators. Care was taken to eliminate the uncertain quantities, and while some steam was used from these boilers for other purposes during the tests, the consumption was believed to be uniform in the separate series of tests with steam and electric driving. The pumps and other steam machinery requiring variable amounts of steam were isolated as far as possible, and were connected to other boilers. (See tables 4 and 5 for statement of those not isolated.) The steam and electrical tests each covered several days, and each included a Sunday, in order to secure figures for light as well as heavy loads. In the steam

TABLE 1.

Comparison of Tests of Turbine Plant.

	Steam. Lbs.	Electric. Lbs.	Difference. Lbs.	Saved. Per cent.	Av.
Combustible, day run....	57,275	37,958	19,317	33.7	
Combustible, night run..	51,011	32,989	18,022	35.3	
Combustible, Sunday....	22,726	14,691	8,035	35.3	
Combustible, Sun. P. M.	23,215	17,440	5,775	24.8	32.2
Equiv. water, day run..	492,697	332,489	160,208	32.5	
Equiv. water, night run.	476,388	279,756	196,632	41.2	
Equiv. water, Sunday...	183,683	96,124	87,559	47.6	
Equiv. water, Sun. P. M.	200,509	109,487	91,022	45.3	41.6
Dry coal, day run.......	66,679	45,905	20,774	31.1	
Dry coal, night run.....	62,386	40,660	21,726	34.8	
Dry coal, Sunday........	27,756	18,066	9,690	34.9	
Dry coal, Sunday P. M.	31,239	22,098	9,141	29.2	32.5

Proportion of loop water of water pumped into boilers, day run, S. P., 4 per cent.

Proportion of loop water of water pumped into boilers, day run, E. P., 1.6 per cent.

Note.—S. P., steam power; E. P., electric power.

tests all the engines shown in Fig. 1 were running except two of 50 h. p and one of 150 h. p for dynamos. In the electrical tests the turbines furnished all of the power except that for lighting the general office and running the arc lights in the foundry.

The water referred to in the tables as "returned by the loops," was water of condensation from the steam supply mains to the engines in Fig. 1. About 4 per cent. of the water evaporated was returned from the pipes by the loops in the steam test, and this was reduced to 1.6 per cent. in the electrical tests, due to a material reduction in the length of steam mains. This will be reduced still more when the steam engines are all taken out. When the power of the engines was measured they were loaded very nearly to their capacity, indicating 949.12 horse power, whereas the total electrical horse power at the switchboard to replace this was about 600. The boilers were tested merely as a means of measuring the fuel consumed. The coal used was all slack in these tests. The moisture runs from 4 to 7 per cent., and the ash from 15 to 25 per cent.

The tables contain the information obtained in the tests in compact form. Table 1 gives a summary of the boiler tests, showing the saving in coal and water for the electric plant and also the saving in condensation returned by the steam loops. Table 2 is a statement of the indicated horse power of

TABLE 2.

Power Required for Machinery.

	H. P.	
Machine Shop.		
Line No. 1	58.10	
Line No. 2	41.09	
Line No. 3	52.90	
Line No. 4	37.08	
Line No. 5	16.26	
Line No. 6	73.41	
Line No. 7	33.38	
Line No. 8	45.49	357.71
Iron Foundry.		
Blast fan	24.60	
Flask conveyor No. 1	14.58	
Flask conveyor No. 2	5.92	
Flask conveyor No. 3	10.53	
Sand conveyor No. 1		
Sand conveyor No. 2	8.81	
Sand conveyor No. 3	15.13	
Sand mixer	4.27	
Sand elevator No. 1, screen and conveyor	14.77	
Sand elevator No. 2, and screen	11.64	
Sand elevator No. 3, screen and conveyor	8.76	
Emery wheels	10.74	
Dust elevator and conveyor	9.85	
Cleaning barrels	9.25	
Lathe and drill press for foundry	5.00	153.85
Blacksmith Shop and Brass Foundry.		
Blacksmith shop	14.21	
Blast fan	18.02	
Exhaust fan	4.60	
Emery wheels	15.00	
Cleaning barrels, sand elevator and conveyor	6.00	57.83
Carpenter Shop.		
Leather room	5.36	
Carpenter shop	19.63	24.99
Pattern Shop.		
Pattern shop	3.42	3.42
Experimental Room.		
Experimental room	5.00	5.00
Light Station.		
No. 707 incandescent light	44.85	
No. 243 for arc light	27.55	
No. 160 load of 50 amp. and eng. friction	121.61	
No. 717 load of 55 amp. and eng. friction	152.31	346.32
Total indicated horse power		949.12

the engines which have been replaced by motors. This shows the amount of power required by the machinery, and it is reproduced in detail in order to give an idea of how thoroughly the work was done in measuring the power for operating the various lines of shafting in the shops and the various other applications of power in the foundry and other parts of the works. It also includes that required for lighting, as the machinery was arranged before the electrical application. All of this power has been replaced by motors receiving current from the turbo-generators, and all were included in the tests except those already mentioned. The exact number of lights used during the tests is uncertain. This factor varied considerably and no record was kept, but it is assumed that it varied uniformly during the different tests. Table 2, of course, includes

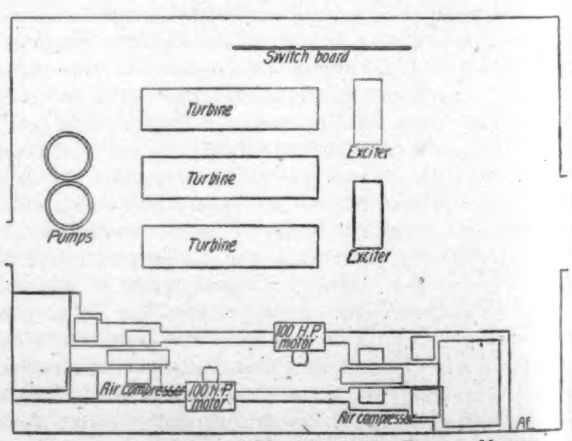


Fig. 4.—Location of Machinery in Power House.

the power consumed in internal friction of the engines. This was an additional load, which was not represented in the electrical tests. It was a legitimate part of the steam-engine load, however.

Table 3 contains a statement of the turbine tests, showing complete data obtained from the turbines, generators and ex-

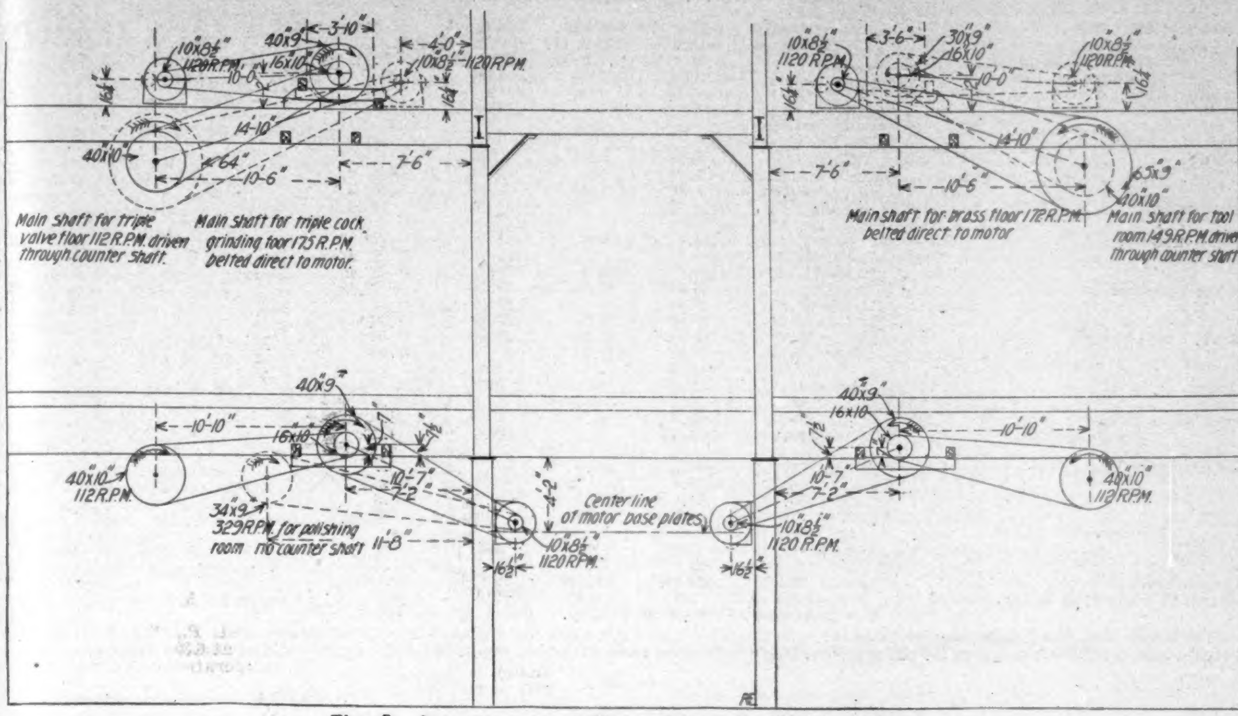


Fig. 3.—Arrangement of Motor Drives in Machine Shop.

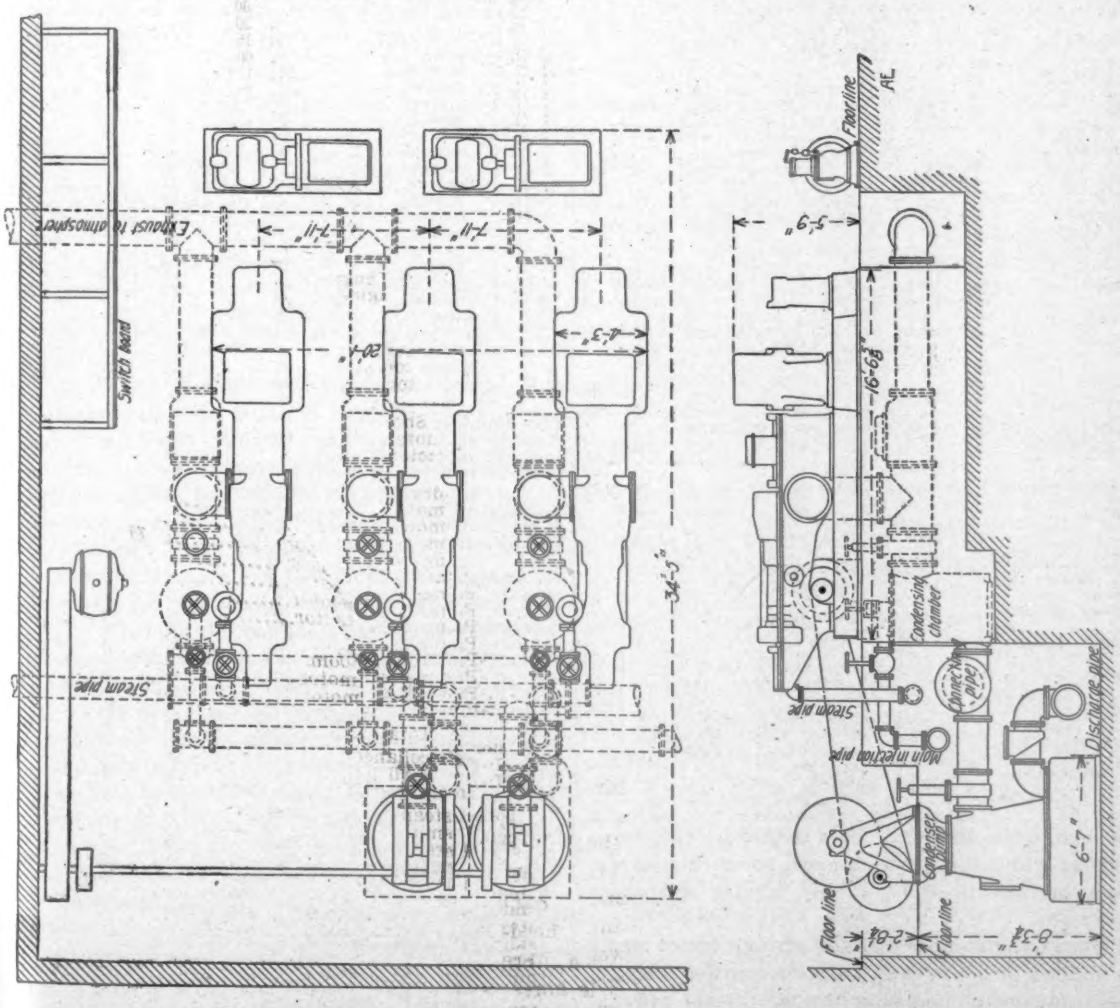


Fig. 2.—Plan and Elevation of Turbo-Generators Showing Air Pumps and Piping.

oilers. These tests were run from 6.30 A. M. to 6 P. M., and from 6 P. M. to 6.30 A. M. In the night runs the power was very small as compared with the day runs, which was due to the fact that the shops are practically shut down at 9.20 P. M., with the exception of the foundry, which is in continuous operation. A wattmeter gave the total number of watts, which, divided by the number of hours, gave the electrical horse-power-hour, as shown in this statement, and indicated as "total electrical horse power." In this table the first line gives the date of the test, the turbines in use are noted, and the number of hours which each one ran. All the readings in this test were figured on a time basis. For example, February 17 the

TABLE 3.—TURBINE RECORD.

Date of test		2-15-1900.	2-15 & 16.	2-16-1900.	2-16 & 17.	2-17-1900.	2-17 & 18.	2-18-1900.	2-18 & 19	2-19-1900.
Duration of test		6:30 A.M. –6 P.M.	6 P.M.– 6:30 A.M.	6:30 A.M. –6 P.M.	6 P.M.– 6:30 A.M.	6:30 A.M. –1 P.M.	6 P.M.– 6:30 A.M.	6:30 A.M. –6 P.M.	6 P.M.– 6:30 A.M.	6:30 A.M. –6 P.M.
" " in hours		11½	12½	11½	12½	6½	12½	11½	12½	11½
No. 1 Turbine in use	Hrs	....	1½	11½	2	...				11½
" 2 " "	Hrs	11½	11	..	10½	5				11½
" 3 " "	Hrs	11½	3	11½	3	6				....
No. 1 turbine	Rev. per min.		3,600	3,548	3,579	....				3,545
" 2 "	Rev. per min.	3,560	3,574	.....	3,600	3,548				3,545
" 3 "	Rev. per min.	3,560	3,546	3,548	3,538	3,556				....
Condensing pump	Rev. per min.	70	71	70	72	71				70
Steam No. 1 turbine	Pressures.	......	114.8	109.6	108.7	....	Turbines did not run.	Turbines did not run.	Turbines did not run.	107.6
" " 2 "	Pressures.	110.9	108.7	......	111.0	110.5				107.6
" " 3 "	Pressures.	110.9	106.8	109.6	108.7	110.2				......
Exhaust No. 1 turbine	Pressures.	......	28.00	27.22	27.28	...				27.66
" " 2 "	Pressures.	27.33	27.87	....	28.10	27.22				27.66
" " 3 "	Pressures.	27.23	27.86	27.22	27.32	27.38				......
Exhaust No. 1 con. pump	Pressures.	27.33	27.86	27.22	27.38	27.46				27.66
" " 2 " "	Pressures.	27.33	27.86	27.22	27.38	27.46				27.66
External air	Temp. Fahr.	37.3	27.8	26.0	26.0	21.0				20.7
Engine room	Temp. Fahr.	68.0	67.1	69.3	67.7	63.0				61.2
Condensing water intake	Temp. Fahr.	40.0	38.8	37.0	37.0	32.0				30.6
" " discharge	Temp. Fahr.	90.1	75 5	95.3	82.8	89.2				92.1
Output of indicated watts, No. 1 Turbine	Elect'l output.	....	46.	228.9	147.9	....				220.
" " " " 2 "	Elect'l output.	206.5	102.4	.....	88.0	221.8				214.
" " " " 3 "	Elect'l output.	205.1	181.4	227.3	181.7	188.8				......
Voltage	Elect'l output.	440	440	440	440	440				440
Volts	Ex-cit-er.	110	110	110	110	110				110
Amperes	Ex-cit-er.	29.3	23.0	30.0	22.7	27.1				30.0
Barometer, inches		29.045	29.149	29.019	29.050	29.050				29.300
Total Elec. H. P. neglecting lamps.		578	249	619	249	477				606
		Thursday.	Thurs. P.M.	Friday.	Fri., P.M.	Saturday.				Monday.

Note.—The boiler tests were made continuously through the three half days when the turbines were shut down. This was to ascertain the comparative steam pipe condensation losses for the complete engine piping system with that required for the electrical distribution system.

TABLE 4.

Summary of Time Run and Nominal H. P., Thursday, February 5th 1900. From Monday Morning at 6.30 A. M. to Tuesday Morning at 6.30 A. M. Operated by Steam.

	Total. H. P.		Time run. Hrs.	Min.	Total H. P. Hrs.	
Machine Shop.						
3 80-H.-P. engines	240		14	7	3,388.00	
1 80-H.-P. engine	80		22	12	1,776.00	
1 5-H.-P. engine	5		22	30	112.50	
1 25-H.-P. engine	25	350	14	10	354.16	5,630.66
Leather Department.						
1 45-H.-P. engine	45	45	10	25	468.75	468.75
Boiler House.						
1 50-H.-P. arc engine	50		17		850.00	
2 50-H.-P. stoker engines	10	60	24		240.00	1,090.00
Light Station.						
1 250-H.-P. engine	250	250	17	40	1,356.66	1,356.66
Blacksmith Shop.						
1 50-H.-P. engine	50	50	23		1,150.00	1,150.00
Iron Foundry.						
1 75-H.-P. engine	75		22	55	1,718.75	
1 35-H.-P. engine	35		21	37	756.58	
1 25-H.-P. engine	25		22	50	570.83	
1 25-H.-P. engine	25		20	40	516.66	
1 25-H.-P. engine	25	185	23	10	579.16	4,141.98
Warehouse.						
1 25-H.-P. engine	25		13	58	349.16	
1 5-H.-P. engine	5	30	10	30	52.50	401.66
Total		970				14,239.71
Miscellaneous. (Not included in above.)						
Valve open on heater ¾ turn, mach. shop			9	10		
3 steam hammers, blacksmith shop			8	15		
1 steam hammer, blacksmith shop			1	40		
1 hydraulic pump, blacksmith shop			10	25		
1 hydraulic pump, iron foundry			24			
1 hot water heater, iron foundry			24			
1 steam siphon, 1-in. outlet, iron foundry			24			

steam pressures seem to be different. This is because one turbine ran five hours while the other ran six hours, giving a different average, but the pressure at any instant was the same on both turbines.

Tables 4 and 5 show the number and size of each motor and engine and the number of hours each was in operation during the tests. These statements also show the total horse power hours, based on the nominal ratings of the engines and motors. This is not important except to give the relative amount of horse power capacity employed during each test. The heading "Miscellaneous" includes various machines which were connected to the boilers during the tests, of which the horsepower capacity could not be determined. The total consump-

TABLE 5.

Summary of Time and Nominal H. P., Thursday, February 15th, 1900. From Thursday Morning, at 6.30 A. M., to Friday Morning, at 6.30 A. M. Operated by Electricity.

	Total H. P.		Time run. Hrs.	Min.	Total H. P. Hrs.	
Machine Shop.						
3 15-H.-P. motors	120		13	50	1,660.00	
1 15-H.-P. motor	15		10	20	155.00	
4 15-H.-P. motors	60		13	55	835.00	
1 20-H.-P. motor	20		13	55	278.33	
1 15-H.-P. motor	15		22	15	333.75	
4 15-H.-P. motors	60		14	5	845.00	
1 15-H.-P. motor	15		10	33	158.25	
1 15-H.-P. motor	15		21	46	326.50	
1 15-H.-P. motor	15		22	5	331.25	
1 15-H.-P. motor	15		13	50	207.50	
1 20-H.-P. motor	20		13	50	276.66	
1 15-H.-P. motor	15		11	13	168.25	
1 20-H.-P. motor	20		10	25	208.33	
1 15-H.-P. motor	15		22	30	337.50	
1 10-H.-P. motor	10		13	50	138.33	
1 5-H.-P. motor	5	435	9	58	49.83	6,309.48
Boiler House.						
2 5-H.-P. stoker engines	10		24		240.00	
1 50-H.-P. arc engine	50	60	14	30	725.00	965.00
Brass Foundry.						
1 20-H.-P. motor	20		21	15	425.00	
1 10-H.-P. motor	10		21	15	212.50	
1 5-H.-P. motor	5	35	15		75.00	712.50
Blacksmith Shop.						
1 30-H.-P. motor	30		14	5	422.50	
1 20-H.-P. motor	20	50	22	40	453.33	875.83
Iron Foundry.						
1 15-H.-P. motor	15		21	3	315.75	
1 15-H.-P. motor	15		21	3	315.75	
1 15-H.-P. motor	15		19	45	296.25	
1 10-H.-P. motor	10		21	3	210.50	
1 30-H.-P. motor	30		22	15	667.50	
1 15-H.-P. motor	15		18	38	278.50	
1 15-H.-P. motor	15		19	58	299.50	
1 15-H.-P. motor	15		21	30	322.50	
1 15-H.-P. motor	15		21	30	322.50	
1 5-H.-P. motor	5		20	53	104.41	
1 10-H.-P. motor	10		22	5	220.83	
1 10-H.-P. motor	10		22	5	220.83	
1 15-H.-P. motor	15	185	21	13	318.50	3,893.32
Leather Room.						
1 15-H.-P. motor	15		22	15	333.75	
1 10-H.-P. motor	10	25	10	25	104.16	437.91
Total		790				13,194.04

Miscellaneous. (Not included in above.)
All lights burned during tests for electric working were fed from power circuits.

	Hrs.	Min.
3 steam hammers (blacksmith shop)	8	5
1 steam hammer (blacksmith shop	1	45
1 Hydraulic pump (blacksmith shop	22	5
No. 1 hydraulic pump (iron foundry	18	50
No. 2 hydraulic pump (iron foundry	23	19
Steam siphon (iron foundry)	24	
Hot-water heater (iron foundry)	24	

TABLE 6.
Test of Babcock-Wilcox Boilers.

Date of test	2-5-1900	2-5 & 6
Kind of fuel	Slack	Slack
Duration of test	6.30 A. M.-6 P. M.	6 P. M.-6.30 A. M.
Duration of test in hours	11½	12½
Number of boilers in use—left battery	8	8
Gauge pressure in boilers per square inch	113.2	107.4
Force of draught in column of water between damper and extreme left boiler, in inches	.500	.509
Force of draught in column of water between damper and extreme right boiler, in inches	1.109	1.057
Force of draught in column of water in main stack, in inches	1.734	1.586
Water in steam loop, Fahr	195.1	192.7
External air, Fahr	33.3	33.5
Fire room, Fahr	63.2	61.0
Cold feed water, Fahr	35.3	35.0
Hot feed water, Fahr	163.5	160.8
Steam, Fahr	343.2	338.5
Moist coal consumed, in lbs	68,000	65,600
Moisture in coal, per cent	3.30	3.08
Dry coal consumed, in lbs	65,756	63,580
Total dry refuse (ashes, etc.), in lbs	8,912	12,382
Total combustible, in lbs	56,844	51,198
Average water returned to boilers by steam loop, lbs	20,016	21.358
Average water pumped into boilers by pumps, lbs	425,203	419,521
Total water pumped into boilers per pump and steam loop, lbs.	445,219	440,879
Proportions:		
Dry coal consumed per hour, in lbs.	5,718	5,086
Total dry refuse (proportion of dry coal), per cent	13.5	19.4
Combustible consumed per hour, in lbs	4,943	4,096
Total actual evaporation of water from pump and steam loop (assumed 98 per cent. dry steam), in lbs	436,314	432,061
Net deduced from preceding:		
Total equivalent water from and at 212° Fahr., in lbs	474.994	470,318
Water actually evaporated per lb. of dry coal, in lb...s	6.63	6.79
Equivalent per lb. of dry coal from and at 212° Fahr., in lbs.	7.22	7.39
Water actually evaporated per lb. of combustible, lbs	7.67	8.43
Equivalent per lb. of combustible from and at 212° Fahr., lbs.	8.35	9.18
H. P. On basis of 34½ lbs. water from and at 212° Fahr., per hr.	1,197	1,091
Number of sq. ft. water-heating surface per horse power	8.82	9.67
H. P. per sq. ft. of grate surface	5.98	5.45
Moist coal consumed (right battery), in lbs	Monday	Monday P. M.

tion of steam in these was believed to be approximately the same in both tests.

Tables 6 and 7 are the logs of the boiler tests for the days for which the consumption of power is given. Table 6 applies to the steam driving and Table 7 to the motors. In Table 8 we have the amount of water evaporated per square foot of grate surface and per square foot of heating surface per hour during the day and night runs, with the differences indicated.

While these tests will not satisfy the stickler for refinements, they show the difference in the two methods of power distribution under every-day working conditions, and that was the object sought. They show that the turbines and motors save 40,000 pounds of coal in 24 hours, including one day and one night run. This is due to the superiority of the entire electrical installation. Part of the saving comes from the turbines, part in reduced lost work, part in the prevention of steam-pipe condensation, and part in more favorable working of the boilers.

We are indebted to Mr. E. M. Herr, General Manager of the Westinghouse Air Brake Co., for furnishing facilities, information and the results of the tests in the preparation of this description. The entire installation was designed and executed under his direction.

The issue of March 16 of "The Railway Age" is a remarkable number. It is exceedingly valuable as a record of the proceedings of the first convention of the American Railway Engineering and Maintenance of Way Association, and contains not only the committee reports but the discussions in full. Aside from these reports the number is valuable for the record of railroad building for 1899 and that in prospect for the current year. Altogether it is a notable and creditable publication.

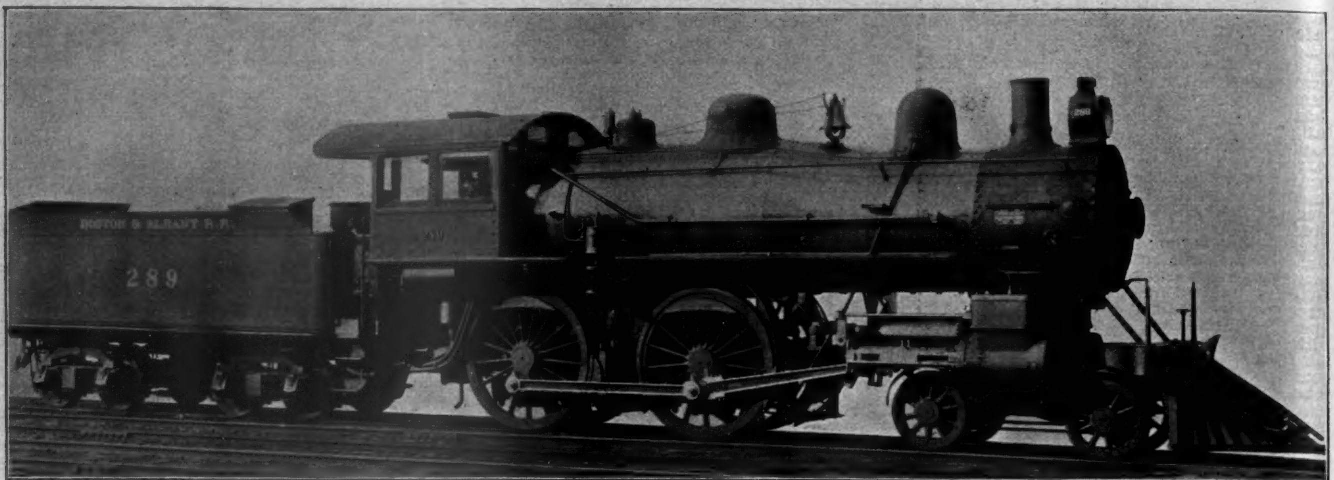
TABLE 7.
Test of Babcock-Wilcox Boilers.

Date of test	2-15-1900	2-15 & 16
Kind of fuel	Slack	Slack
Duration of test	6.30 A. M.-6 P. M.	6 P. M.-6.30 A. M.
Duration of test in hours	11½	12½
Number of boilers in use—left battery	8	8
Gauge pressure in boilers per square inch	114.6	114.0
Force of draught in column of water between damper and extreme left boiler, in inches	.437	.245
Force of draught in column of water between damper and extreme right boiler, in inches	1.031	1.072
Force of draught in column of water in main stack, in inches	1.656	1.485
Water in steam loop, Fahr	177.1	177.1
External air, Fahr	38.6	28.6
Fire room, Fahr	65.7	60.0
Cold feed water, Fahr	45.0	41.5
Hot feed water, Fahr	159.5	171.6
Steam, Fahr	343.6	343.3
Moist coal consumed, in lbs	48,400	42,800
Moisture in coal, per cent	5.75	5.27
Dry coal consumed, in lbs	45,617	40,544
Total dry refuse (ashes, etc.), in lbs	9,012	8,000
Total combustible, in lbs	36,605	32,544
Average water returned to boilers by steam loop, lbs	5,429	5,902
Average water pumped into boilers by pump, lbs	306,828	253,678
Total water pumped into boilers per pump and steam loop, lbs.	312,257	259,580
Dimensions and proportions.		
Grate surface of each boiler, sq. ft.	25	
Grate surface, total, sq. ft	200	
Water-heating surface of each boiler, sq. ft	1,320	
Water-heating, total, sq. ft	10,560	
Ratio of water-heating surface to grate surface	52.8	
Dry coal consumed per hr., in lbs.	3,967	3,244
Total dry refuse (proportion of dry coal), per cent	19.75	19.73
Combustible consumed per hour, in lbs	3,183	2,604
Total actual evaporation of water from pump and steam loop (assumed 98 per cent. dry steam), in lbs	306,012	254,388
Net deduced from preceding:		
Total equivalent water from and at 212° Fahr., in lbs	333,447	274,681
Water actually evaporated per lb. of day coal, in lbs..	6.70	6.27
Equivalent per lb. of dry coal from and at 212° Fahr., in lbs.	7.30	6.77
Water actually evaporated per lb. of combustible, lbs	8.35	7.81
Equivalent per lb. of combustible from and at 212° Fahr., lbs.	9.10	8.44
H. P. on basis of 34½ lbs. water from and at 212° Fahr., per hr.	8.40	6.37
Number of sq. ft. water-heating surface per horse power	12.56	16.58
H. P. per sq. ft. of grate surface	4.20	3.18
Developed electrical H. P., neglecting lamps on switchboard	578	249
	Thursday	Thursday P. M.

TABLE 8.
Statement of Amount of Water Evaporated.

	Steam.	Electric.	Difference.
Total lbs. water evaporated per sq. ft. grate surface per day of 11½ hours	2,463.48	1,662.44	801.04
Total lbs. water evaporated per sq. ft. grate surface per night of 11½ hours	2,381.94	1,398.78	893.16
Total lbs. water evaporated per sq. ft. grate surface per hour (day)	214.21	144.56	69.65
Total lbs. water evaporated per sq. ft. grate surface per hour (night)	207.12	121.63	85.49
Total lbs. water evaporated per sq. ft. water heating surface, per day of 11½ hours	46.65	31.48	15.17
Total lbs. water evaporated per sq. ft. water heating surface, per night of 11½ hours	45.11	26.49	18.62
Lbs. water evaporated per sq. ft. water heating surface per hour, day run	4.05	2.74	1.31
Lbs. water evaporated per sq. ft. water heating surface per hour, night run	3.92	2.30	1.62
Temperature, fire room, Fahr	63.2		61.0

Large orders for locomotives have been placed since our previous issue. The Pennsylvania has ordered 40 of the Baldwin Locomotive Works for heavy freight service. The Lake Shore & Michigan Southern has ordered 25 consolidation freight and five ten-wheel passenger engines from the Brooks Locomotive Works, and among the smaller orders is one for six Baldwin compounds for the Rock Island. This is a new departure for this road.



Eight-Wheel Passenger Locomotive.—Boston & Albany R. R.

T. B. PURVES, *Superintendent of Rolling Stock.* SCHENECTADY LOCOMOTIVE WORKS, *Builders.*

EIGHT-WHEEL PASSENGER LOCOMOTIVE.

Boston & Albany Railroad.

When the Schenectady Locomotive Works built two eight-wheel passenger engines in 1894 for the Boston & Albany, with a total weight of 114,700 pounds, weight on drivers 74,000 pounds, and a total heating surface of 1,844.7 square feet, they were considered wonderful in size and power. These engines may be considered as marking the beginning of the use of large heating surfaces in engines of this type. They were followed, two years later, by engines of the same type, and same builders, for the Big Four. These had 2,175 square feet of heating surface, with a total weight of 126,000 pounds, and 83,000 pounds on drivers. The Chicago & North Western Class A engines, built in the same year, were similar to the Big Four engines, but not quite as powerful. Last year these works furnished two eight-wheel designs to the C. & N. W. (American Engineer, June, 1899, p. 189, and July, page 224), which surpassed previous designs in heating surface per unit of weight on driving wheels. The heavier and more powerful of these weighed 137,000 pounds in working order, with 87,000 pounds on driving wheels, and had 2,507.75 square feet of heating surface.

We now illustrate a new eight-wheel engine for the Boston & Albany, for use between Springfield and Boston, which, for its weight, has more heating surface than any brought out previously. This engine, with a total weight of 136,400 pounds, and 88,500 pounds on drivers, has a total heating surface of 2,505.27 square feet. It has two more tubes than the C. & N. W. engine, but no arch tubes. If these tubes were used, about 15 feet of heating surface would be added.

A matter of a few feet of heating surface seems trivial. It is so when considered by itself, but as an indication of a tendency in locomotive design it is most important. We desire to direct particular attention to the comparison between engines of the same type in six years, as follows:

Schenectady Eight-Wheel Locomotives.

	B. & A. 1894.	Big Four. 1896.	B. & A. 1900.
Total weight	114,700	126,000	136,400
Weight on drivers	74,000	83,000	88,500
Total heating surface	1,844.7	2,175	2,505.3

With an increase of 18 per cent. in total weight, the heating surface increased 35 per cent. in little more than five years.

In general the design resembles those for the C. & N. W. already referred to. It will be noticed that this is a very handsome engine. The greatest credit due to the builder is, however, the large heating surface for the weight. This was not obtained by using long tubes, for these are but 13 feet long. The chief dimensions are given in the following table:

General Dimensions.

Gauge	4 ft. 8½ in.
Fuel	Bituminous coal
Weight in working order	136,400 lbs.
Weight on drivers	88,500 lbs.
Wheel base, driving	8 ft. 6 in.
Wheel base, rigid	8 ft. 6 in.
Wheel base, total	24 ft. 8½ in.

Cylinders.

Diameter of cylinders	20 in.
Stroke of piston	26 in.
Horizontal thickness of piston	5 ft. 4½ in.
Diameter of piston rod	3¼ in.
Size of steam ports	18 in. by 1⅝ in.
Size of exhaust ports	18 in. by 3 in.
Size of bridges ports	1⅜ in.

Valves.

Kind of slide valves	Allen-Richardson
Greatest travel of slide valves	6 in.
Outside lap of slide valves	1⅛ in.
Inside lap of slide valves	0 in. line and line
Lead of valves in full gear	3/16 in. blind in full forward motion and shift backing ecc. to give ¼ in. lead at 6-in. cut-off.

Wheels, Etc.

Diameter of driving wheels outside of tire	75 in.
Material of driving wheel centers	Cast steel
Driving box material	Cast steel
Diameter and length of driving journals	9 in. dia. by 11½ in.
Diameter and length of main crank pin journals	6 in. dia. by 6 in.
Diameter and length of side rod crank pin journals	F. & B. 4½ in. dia. by 4 in.
Kind of truck	4-wheel rigid center
Truck journals	6 by 12 in.
Diameter of engine truck wheels	36 in.
Kind of engine truck wheels	Krupp No. 3

Boiler.

Style	Extended wagon top
Outside diameter of first ring	64 in.
Working pressure	190 lbs.
Material of barrel and outside of firebox	Carbon steel
Thickness of plates in barrel and outside of firebox	7/16 in., ½ in., ⅝ in., 11/16 in.
Firebox, length	108⅛ in.
Firebox, width	40⅜ in.
Firebox, depth	F. 79¾ in., B. 66¼ in.
Firebox, material	Carbon steel
Firebox plates, thickness	Sides 5/16 in., back 5/16 in., crown ⅜ in., tube sheet ½ in.
Firebox, water space	Front 4½ in., sides 4 in., back 4 in.
Firebox, crown staying	Radial, 1 in. dia.
Firebox, staybolts	Taylor iron, 1 in. dia.
Tubes, material	Charcoal iron, No. 12
Tubes, number of	344
Tubes, diameter	2 in.
Tubes, length over tube sheets	13 ft.
Heating surface, tubes	2,326.53 sq. ft.
Heating surface, firebox	178.74 sq. ft.
Heating surface, total	2,505.27 sq. ft.
Grate surface	30.33 sq. ft.
Grate, style	Rocking
Ash pan, style	Single hopper dampers F. & B.
Exhaust pipes	Single high
Exhaust nozzles	4¾ in., 5 in., and 5¼ in. dia.
Smoke stack, inside diameter	15 in.
Smoke stack, top above rail	14 ft. 4 in.
Boiler supplied by	One twin inspirator, Hancock No. 90

Tender.

Weight, empty	44,400 lbs.
Wheels, number of	8
Wheels, diameter	36 in.
Journals, diameter and length	5 in. dia. by 9 in.
Wheel base	15 ft. 10 in.
Tender frame	Iron. B. & A. standard
Tender trucks	2 4-wheel, side bearing, wood bolster and
Tender frame	Iron, B. & A. standard
Water capacity	5,200 U. S. gallons
Coal capacity	9 tons

CORRESPONDENCE.

ARRANGEMENT OF TRACKS IN ERECTING SHOPS.

To the Editor:

In the March issue of your paper, page 80, I notice an editorial on the question of arrangement of tracks in erecting shops, in which you state that some time ago you gave considerable space to the subject, rather favoring the longitudinal plan and appearing to invite support from that point of view. The criticisms which are offered and which are in favor of the transverse arrangement do not appear to have very much force, as the statements are more general than particular.

In the lateral or transverse shop arrangement only one crane can be used to lift an engine, and if the engine weighs 100 tons it requires a crane of 100 tons capacity to lift it—that is, a crane having two crabs or trolleys, each having a capacity of 50 tons. The engines are not lifted so often in the transverse arrangement, as they are not lifted in order to place them, which has to be done by other means; but, on the other hand, if the engines are placed longitudinally and two cranes each of 50 tons capacity are supplied, there are two cranes available for general purposes as against one in the other system, and as the lifting of engines does not occupy five per cent. of the time which the cranes are in service, it follows that nearly twice as much service in other work is to be had with two cranes as against one, which, as a matter of course, very much facilitates progress of work in the shop.

If the lateral system is adopted and only one crane used, it has to be supplemented by an out-door traverser or transfer table. This traverser can only be used for the handling of engines and does not facilitate the work in the shop at all, but the cost, including pit, etc., if it is arranged for quick service, is a large proportion of that of the crane of equal capacity. This traverser, being in a pit, is a great obstacle to communication between shops, and the loss of time of employees in passing around it and over the extra distance which it occupies is an unknown but important amount. The supposition that, because longitudinal tracks are used, it is necessary to lift one engine over another, is entirely wrong. This is not at all necessary, and greater height of lift is not required in a longitudinal shop than in the lateral one. In cold climates also the lateral system, which necessitates a pair of doors for each pit, is a direct drawback.

Suppose the shop was required to hold thirty engines. If these were put in one row side by side, then the shop becomes unmanageable from its length and the traverser pit is also unduly long. If they are put in two rows with engines on one side of the shop only, then one engine is in the way of the other. If they are put in two rows with the doors in opposite sides of the shop, then it requires two transfer tables and the erecting shop totally isolated from the rest of the building, unless they are put in the end, which is an inconvenient arrangement.

The most important argument of all, however, is that it is practically impossible to properly supervise a shop in which the engines are arranged laterally. If the shop is sufficiently large to fully occupy the foreman's time, it is impossible for him to give the same supervision that it is possible to exercise in a shop arranged longitudinally, where he can see the whole length of the shop when he walks across it. This is a practical observation from the writer's personal knowledge and is a serious detriment against a shop arranged laterally. The lateral system is good enough for a road which requires eight to ten engines under repair at one time, but it is not suitable for a road which has a large number of engines passing through the shops.

SUPERINTENDENT OF MOTIVE POWER.

March 5, 1900.

STAYBOLT PROGRESS.

To the Editor:

Staybolts are so important in locomotive repairs that I desire to offer a few remarks, if not too late, in connection with the article in your December number of last year, page 382, and the correspondence on page 8 of the January number of this year.

In the first place, the form of the firebox is of importance as to the number and location of staybolts broken. We have always found that a sharp "ogee" connecting the flat side of the firebox with the circular portion is extremely destructive, and it is a common thing to find a whole row or two lengthwise of the box broken off at that point, more especially with the deep class of firebox, and I presume everyone else has found the same thing. The next most troublesome part is the front upper corners and then the back upper corners and the top row across the back sheet. We have also found that an increase in the thickness of the outside plate materially increases the number of broken staybolts, and for a number of years we have never used anything thicker than 7/16 inch outside sheets, and I am disposed to think that the Pennsylvania Railroad will find an improvement by the use of ⅜ inch outside side sheets. The diameter of the bolt does not appear to make much difference, and bolts 1¼ inches or 1⅛ inches diameter appear to fail just as quickly as bolts ⅞ inch or 1 inch diameter.

We tried turned down staybolts for a year or two without any benefit that could be seen, the staybolts being turned about 1/32 inch below the bottom of the thread and carefully rounded at the ends. We have had a considerable number of engines equipped with staybolts drilled at the outer end, but have had failures occurring earlier and more prevalent than with solid bolts, and we have never derived any benefit in the way of the supposed leakage indicating a broken bolt as they are always full of mud both in the crack and in the hole.

All staybolts appear to fail by cracking across the upper and lower sides near the outside sheet, leaving a strip across the center to break off last. The upper crack usually is deeper than the lower one, and in the case of the upper corner of the side sheets the cracking is not quite horizontal but inclined a little downward toward the outer end of box. If staybolts could be made with a flat horizontal section to allow them to spring, it would appear likely to conduce to longer life.

The conclusions at the termination of the article appear to be generally correct. I have not noticed any deflection of the side sheet due to reaming, mentioned by Mr. Gillis, which may be due to the fact that the taps which we use do not have the blunt-ended reamer, but have a long tapered end to form a guide and the reamer portion is cut some distance up the shank. I quite agree with Mr. Gillis that it is almost impossible to get two staybolt taps exactly alike. We overcame this to some extent by using a pair of taps alternately, keeping each to its own vertical row, and the bolts are screwed to suit the two taps and put in the holes to correspond. We make all our own staybolt taps and keep them as nearly as possible to a standard fixed a number of years ago. Staybolts which are made of iron piled in slabs, as mentioned in your article in the middle of the second column, page 384, distinctly show the marked difference between the durability of the bolts, if the staybolt is placed in with the seams horizontally and vertically, the former being much more durable. One brand of iron particularly shows this very plainly.

R. ATKINSON,
Mechanical Superintendent Canadian Pacific Ry.

Montreal, March 9, 1900.

The first example of the ten-wheel type locomotive ever built is illustrated in a recent issue of the "Railway Age." It was built by the Schenectady Locomotive Works in 1887 and went into service on the Michigan Central R. R. in January, 1888. It is still in service.

The new passenger engines for the Lake Shore (November issue, page 344) are exceedingly handsome. The driving wheels are large, so is the boiler, which is also very long, and yet the proportions are so well balanced as to give a most pleasing appearance. One minor detail which contributes its share is the location of the headlight in advance of the stack, and yet not overhanging the front end.

New rails are being laid by the Ontario & Western, contracted for in 1898 at $18 per ton, while the same road is selling scrap rails at $33. The cost of laying the new ones is about $3 per ton, a very interesting situation for the road. The figures will change, however, when it is necessary to make new contracts, the price of new rails being now nearly $40 per ton.

ELECTRICITY AT THE DUQUESNE STEEL WORKS.

By Burcham Harding.

One of the best examples of modern direct-current "engine-type" generators is found at the Duquesne Works of the Carnegie Steel Company, twelve miles from Pittsburg. The central power station contains three 400-kilowatt Westinghouse direct-current generators, 250 volts, direct connected to horizontal tandem-compound steam engines, operating at 130 revolutions per minute. A view of the interior of the dynamo room is given in Fig. 1. In the background of the illustration are shown six direct constant-current 60-light arc dynamos, which supply current to arc lamps in the various buildings and yards. These machines are direct connected by flexible insulated couplings to six 50-horse-power shunt motors, which are operated by power from tne generators.

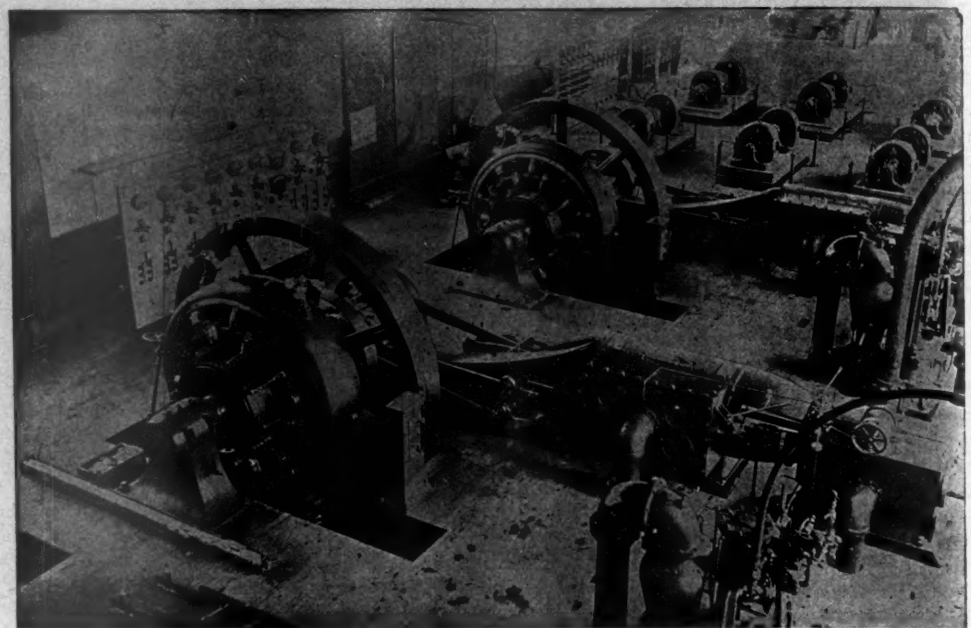


Fig. 1.—Interior of Power House. Duquesne Works, Carnegie Steel Co.

Power is conveyed to the several departments of the works, which cover an area of over 100 acres. There are over 40 electric cranes in the plant, driven by 220-volt direct-current Westinghouse motors. Other motors are used to operate the metal breaker, and for conveying iron ore from railway cars to the ore stock yard, and thence by the traveling bridges to the furnaces. In fact, electric power enters into every operation in these works.

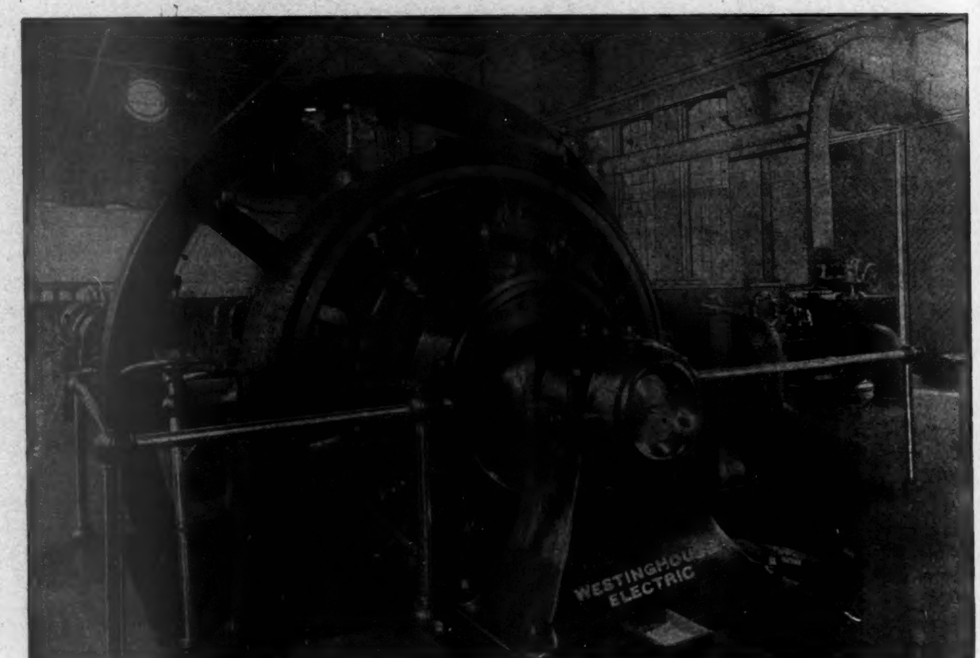


Fig. 2.—One of the 400 Kw. Westinghouse Generators. Duquesne Works, Carnegie Steel Co.

The generators, one of which is shown in Fig. 2, represent the latest development in design and construction. They furnish current at 250 volts, and as the usual practice is to employ 220-volt motors, this allows 30 volts drop of potential in the line. The use of 250-volt generators also permits the operation of both arc and incandescent lamps from the motor circuits. The general design of these engine-type generators is similar to that for standard multipolar practice, consisting of a circular yoke carrying inwardly projecting pole pieces of laminated soft steel. The field castings are divided vertically and set upon a guide plate, the former affording excellent facility for inspection or removal of the armature or field coils.

These generators are compounded to compensate for the drop of potential in the line. The shunt and series coils are separately wound and are removable. The series coils are composed of forged copper conductors of rectangular section. The armature core consists of punched disks of carefully annealed steel, held together between end plates. This core is built upon an iron spider, which also carries the commutator. This spider is pressed and keyed upon the extended shaft and may be drawn off without in any way interfering with the permanent arrangement of the commutator and winding. Ventilating spaces through the spider and armature core are so arranged as to allow a constant circulation of air through the commutator and winding when the machine is running.

The periphery of the armature is slotted. The armature winding is made of bars of drawn copper which, after being shaped, are thoroughly insulated and baked to remove all moisture. The coils are held in the slots by retaining wedges of hard fiber, driven into notches near the top of the slots, parallel with the shaft. These fiber wedges may be pressed out should it become necessary to remove any armature coil. The commutators are constructed from the best obtainable grade of hard-rolled copper, the segments being spaced by prepared mica of such corresponding hardness that an extremely even wearing surface is presented to the brushes.

The brush-holder mechanism is carried by brackets projecting from a ring concentric with and supported by the field. A hand-wheel rocker arrangement adjusts all the brushes simultaneously. It will be noted that the ring carrying the brush-holder brackets does not project over the commutator face, thus leaving the commutator face and brushes clear of obstruction and easy of inspection at any point. Carbon brushes are used in connection with all of these machines. During construction all parts of these machines are submitted to a series of thorough tests and inspections. When assembled and completed, each machine is given a full-load running test of sufficient duration to bring it to the maximum temperature.

The electric motors operated by the current from this generating station has enabled the management to remove several separate steam engines which were very costly in the consumption of steam. It was found that many of these separate steam engines used 70 pounds of steam per horse-power hour, whereas the consumption of steam at the central power house does not exceed 16 pounds. The President of the company has stated that the intermittent operation of the motors is carried on from the central station by means of one-sixth of the horse power previously required when separate engines were used.

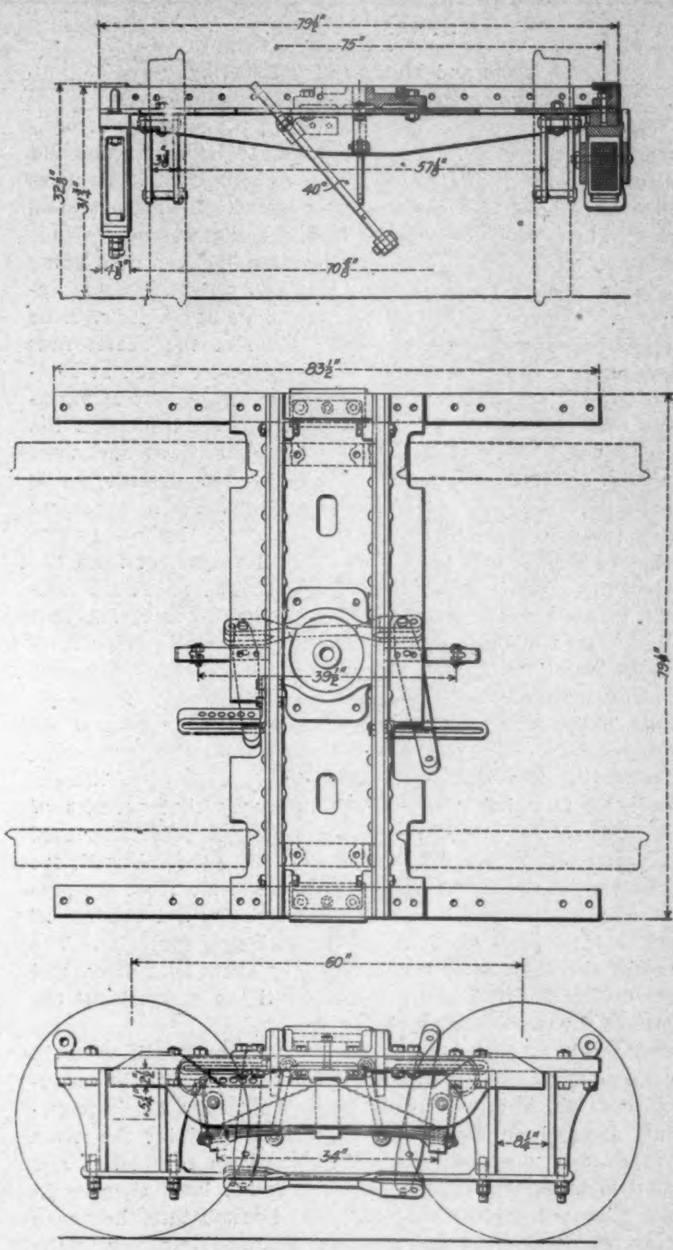
STANDARD TENDER TRUCK.

Lehigh Valley Railroad.

The Lehigh Valley standard truck for tenders using the 4¼ by 8-inch axle is shown in the accompanying engravings. The arrangement in general is not new. It is interesting, however, because of the arrangement of the details whereby the construction is simplified and cheapened and at the same time the benefits of equalization are secured. This design was brought out in 1896 and it is used on all new engines except those having 7,000-gallon tanks. These large tanks are used in connection with heavy mountain pushing locomotives and were illustrated on page 10 of our January issue. The consolidation road locomotives described on page 250 of our August issue are also to be equipped with them. The journals under these large tenders are 5 by 9 inches and Fox pressed steel trucks are used under cars as well as tenders which require these large axles.

The tender truck design was prepared with a view of requiring the minimum amount of machine work. Jigs are used to lay out and drill all the holes and the riveting is done in a pneumatic press. The side frames are made of merchant iron, unplaned, and the castings are made in such forms as to require very little machine work. The transom angles are commercial shapes with the wheel and brake lever clearances punched out. The springs are standard driving springs, by which the necessity for carrying a special spring in stock is avoided. The whole truck is made by piecework and at the lowest cost that we have ever seen. Yet the cost of maintenance is also small, which indicates that durability and safety are not sacrificed.

An examination of the drawings shows the frame rails to be of 2 by 4½ inches bar iron, the tie rod being of ¾ by 4-inch iron. The truck transom is a 15-inch channel with the flanges turned up. Outside of the flanges of this channel are 1¼-inch bars and 4 by 6-inch angles riveted together. The bars are 6 inches deep at the ends and 10 inches at the center. Clearances are cut in the angles for the wheels and the brake levers. The equalizers are 1 inch thick and 6 inches deep at the center, tapering to a depth of 5 inches at the bearing points. The springs have 19 leaves ⅜ inch thick and 4 inches wide, and are 34 inches long between bearings when under load. The height of the springs under a load of 19,000 pounds is 9⅛ inches; under 18,000 pounds, 9¼ inches; under 17,000 pounds, 9⅜ inches, and under 16,000 pounds, 9½ inches. They are designed to carry 19,500 pounds with a set of 1 inch. The axles have the M. C. B. 4¼ by 8-inch journals and journal boxes, and the wheels are 36 inches in diameter.



Standard Tender Truck.

Lehigh Valley R. R.

For the drawings we are indebted to Mr. S. Higgins, Superintendent of Motive Power, and to Mr. F. F. Gaines, Mechanical Engineer of the Lehigh Valley Railroad.

The important facts regarding circulation in steam boilers, as viewed by "Engineering News," are summed up in a recent issue of that journal as follows: "Circulation in a boiler is of value, and should always be secured to a sufficient extent to keep the heating surface bathed in water and to prevent their undue heating and the injury of the boiler through unequal expansion. The more rapid the circulation, the better will this end be attained; and some gain is also to be secured through the reduced tendency of sediment to deposit on the heating surface. It is in these directions and not in any increased evaporative efficiency that the gain from good circulation is to be found. While in theory rapid circulation should very slightly improve the economy of a boiler, the gain is too slight to be discernible by any practical tests."

STEAM GAUGES.

Tests and Method of Connecting.

Wide and even dangerous variation in the readings of ordinary locomotive steam gauges have been found on a prominent railroad as a result of a series of tests or comparisons of gauges which have now been carried on systematically for over two years. The gauges are removed from the engines and readings are taken at intervals of 10 pounds ascending and descending the scale, the comparisons being made by weighted piston apparatus. The records of the tests are made on sheets of cross section paper and preserved until some of the charts now show eight or nine records of the same gauge taken at sufficient intervals to indicate the character and extent of variations that are caused by ordinary service conditions on the locomotives. Many of the lines are very crooked and some show errors of 15 pounds at the blowing off pressure, while others show an error of as much as 60 pounds at pressures below 100 pounds. The curves include all of the well known makes of gauges and as a rule they all vary least from the correct pressure at the blowing off point. The errors are sufficient in extent and abundance to force the conclusion that gauges ought to be followed up carefully entirely aside from the consideration of safety, because of the important influence of steam pressure upon the economical working of locomotives. These tests at once form a basis for comparison of the merits of the work of the various makers and as the differences in reliability are marked a test of six gauges by different makers is now being conducted in a way that permits of securing uniform conditions for all. The gauges are mounted in a frame on a road locomotive and fixed to the cab wall, out of the way of the men. They all receive steam from the pipe that supplies the engine gauge, and steam can not be shut off from them without shutting off his working gauge also. The faces of the six gauges are blanked by sheet iron discs, and after testing them they are to run until the comparisons are complete, frequent readings being recorded.

One result of this investigation is to show weak spots in arrangement and in construction used by certain of the manufacturers, which have already been the means for improvement. It has been shown that the method of piping the steam to a gauge is more important than has been considered, and that it is necessary to use siphons of rather large capacity in order to guard against the entrance of steam into the gauge spring, an occurrence that seems to be possible owing to the expansion of the spring, if the siphon is too short. The gauges on the road referred to are now fitted with the usual siphons at the gauge connection, and instead of carrying the copper tube to the boiler direct it is given two turns around the back of the gauge. This long tube is filled with water, and besides adding to the volume of the contents of the siphon, it tends to keep the temperature of the gauge spring more uniform. Its effect appears to be to render the actions of a gauge more uniform and reliable.

Prof. Ripper says that the importance is admitted of maintaining a column of water in the syphon of the pressure gauge to keep the gauge cool, so that its readings may be consistent, and so as not to subject the gauge to high or variable temperatures. It is generally supposed that if the gauge has a syphon there is always water in it, and that when the syphon is once full of water the water is easily retained therein, but these assumptions are not warranted by the facts. The water will disappear from the syphon from various causes. If there is the smallest leak in the gauge end of the syphon, then the water is all gone in a minute or two by being blown out by the steam, though the leak may be almost imperceptible. If the pressure to which the gauge is subjected is a variable one, the water will disappear from the syphon as usually constructed in a few minutes, especially on a sudden reduction of pressure in the same way that water in the engine cylinder disappears during expansion and exhaust."

MECHANICAL STOKERS.

Why They Sometimes Fail.

In a discussion of the subject of combustion in stationary boiler furnaces and mechanical devices for firing them, Mr. W. E. Snyder offered the following conclusions before the Engineers Society of Western Pennsylvania:

1st. The phenomena of combustion are governed by certain laws which must be obeyed if good results are to be obtained.

2d. The test of the action of any boiler furnace is the character of its products, solid and gaseous.

3d. It is not possible to work the common grate as used in the ordinary manufacturing plant in accordance with the laws of combustion.

4th. Devices which are used as auxiliaries to common grates may, under favorable conditions, be beneficial, but usually simply complicate matters without compensating for the disadvantages of the common grate.

5th. Mechanical stokers should effect a saving over common grates, but in some cases this saving may be neutralized by certain losses co-existent with the operation of the stoker.

6th. The failure of mechanical stokers to produce satisfactory results is probably due more frequently to inattention on the part of superintendents, carelessness on the part of the men who operate them, or a dense ignorance of the entire subject of combustion on the part of all concerned, than it is to actual defects in the principle or action of the machine itself.

A cause of increased flange wear on car wheels was given by a correspondent of the "Railroad Gazette," as arising from the shallowness of the chill in the throat of the wheels. According to this correspondent it is only in the last few years that this increase in the wear of flanges has been noticeable. The iron used in earlier days, which was soft gray iron, with coarse granular fracture, was far more sensitive to chill and made an ideal car wheel metal. It was rich in carbon and poor in all other elements and would take a chill almost as deep in the throat as on the tread. But such iron cannot be obtained now for making wheels. It is possible to obtain the same depth of chill with the iron used in making wheels at the present time, but it is done at the expense of the softness and ductility of the gray portion of the wheel. It, therefore, seems necessary with the irons used at present, to reduce the chilling qualities of the metal in order to meet the "thermal test." And while the depth of chill upon the tread of the wheel is sufficient to withstand long wear, the chill in the throat is often deficient.

The sand blast has been used with marked success in cleaning the iron lock gates of the Muscle Shoals Canal on the Tennessee River. The report of Major Kingman, of the Corps of Engineers, U. S. A., describes the apparatus used. It was placed under a roof on a barge and consisted of a 12 by 14 inch stationary engine and a pair of 9 by 9 inch Clayton direct coupled air compressors. The air was compressed into several receivers from the last of which three blast pipes were carried to the sand drums, the blast being controlled by valves. Each blast pipe terminates in a piece of hose about 25 feet long with a ⅜-inch tool steel nozzle at the end. There are two 18 inch sand drums 4 feet long for each blast pipe. These are in duplicate so that one may be filled while the other is in use and the work be carried on continuously. The drums are filled from a large hopper extending over all of them. Into this the sand is put after screening and drying. A ½-inch pipe admits air pressure to the top of each drum. Records for the year ending June 30, 1898, showed that for a total of 44,522 square feet of iron work cleaned and painted the cost was but 2.8 cents per square foot.

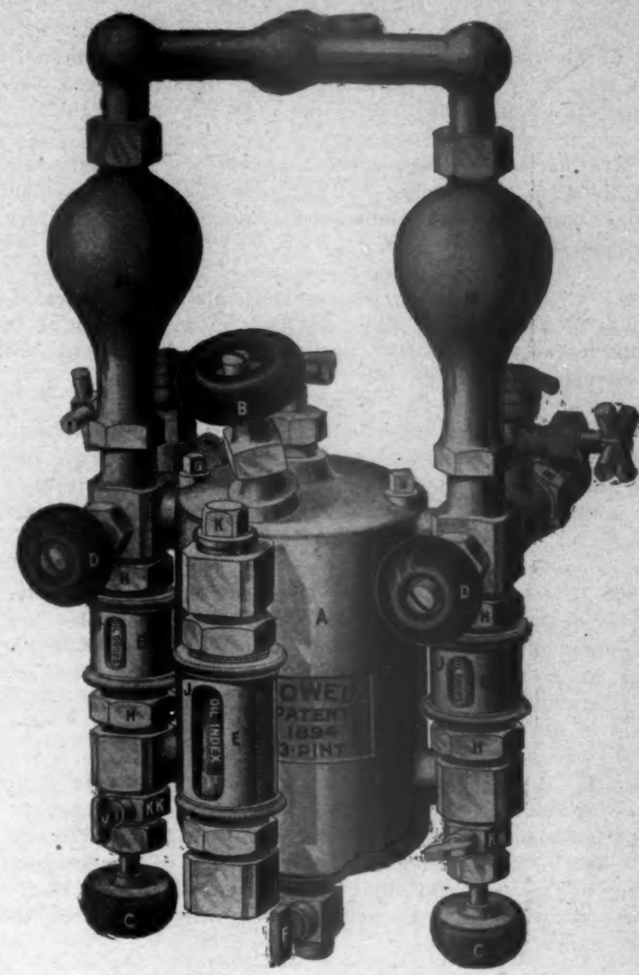
A METHOD OF BENDING PIPE.

The bending of pipes of relatively large diameter without distortion or weakening is a rather difficult process and with the large number of arch tubes in use in locomotive fireboxes this work is often necessary in locomotive shops. If pipes could be bent without difficulty probably advantage would often be taken of easy bends, instead of using the abrupt turns involved in standard fittings. Formers may be used for pipes of small diameters, but for those requiring heating the following practical suggestions offered by Mr. R. H. Perry, in "Machinery" will be found useful:

The most practical method under such circumstances is to fill the pipe to be bent with perfectly dry sand and plug or cap the ends so that the filling will be retained under quite severe handling. Care should be taken to have the pipe well filled with the sand and that there is nothing inflammable or damp in it, as the necessary heating of large pipes is very likely to cause a serious explosion. The heating of the pipe may be done in an ordinary forge, and should be restricted to the part of the pipe that is required for the bend; also overheating should be avoided, as the loss from scaling has a very appreciable effect on the bursting strength. The best results will be obtained when the heat is not carried above a dull red, as the liability to kinking is less, and in any case it is usually necessary to heat two or three times before a sharp bend can be satisfactorily made, so that nothing is gained by heating to a high temperature. A can of water should be provided, which should have a spout so that a small stream can be directed exactly where needed, as its proper use plays an important part in securing bends without kinks, a point which is highly desirable, as a kink is always an eyesore in the appearance of a pipe, besides seriously reducing its capacity at that point.

After the pipe has been heated to the proper temperature, it is clamped in the vise as close to the location of the bend as possible without grasping the red hot part and the bend started, but first the outside of the curve should be cooled with water carefully applied from the can. The inside of the bend being hot and plastic is compressed as the bend is made with very little tendency towards flattening, but if such a tendency develops, it can be corrected by loosening the pipe and using the jaws of the vise to bring the flattened part back to an approximately circular section. The reason for applying the water to the outside of the curve is that by forcing the bend to take place on the inside of the curve, the pipe walls are better supported by the filling, for the reason that the cubic contents are slightly reduced by the compression; whereas if the exterior of the curve be allowed to stretch, the cubic contents are slightly increased, which allows a small amount of slackness in the filling at that point and a consequent lack of support to the interior of the pipe. The use of water also plays an important part in the proper formation of the curve, as by its use the pipe may be cooled at a point where the required curvature has been obtained and still leave the remainder in a condition to be bent as desired. When bending pipe without formers it is necessary to have a template, which may be made from a ¼-inch rod bent to the desired curve and which, being laid on the pipe while bending, gives a guide for the operator. The use of water for cooling the outside of the curve can usually be dispensed with when the radius equals or exceeds fifteen times the diameter of the pipe.

Most expensive mistakes in the construction of the Siberian Railroad are reported by R. T. Greener, Commercial Agent of the United States at Vladivostok. He states that the rails on both the Siberian and the Trans-Baikal lines are too light and that many of the cheap wooden bridges are failing. The result is that speeds are reduced to 20 miles an hour. From this report the location seems to have been faulty and the general condition of the road very bad. Apparently not less than $7,725,000 will be required to put the Trans-Baikal line in running order, and the whole Siberian road will require $25,750,000, so much of the work must be done over again.



Powell's Locomotive Lubricator.

POWELL'S LOCOMOTIVE LUBRICATOR.

The accompanying engraving illustrates a sight-feed lubricator for locomotives, known as Powell's "Star" duplex condenser lubricator. It has a double up-feed and is a radical departure from former styles of single condenser cups, and overcomes the difficulty of "cross feeding" on syphoning the oil wastefully from the lubricator to one of the cylinders at the expense of the other cylinder. This results in too much lubrication in one cylinder and too little in the other, and it is specially likely to occur when the engine is drifting with steam shut off. In this lubricator each cylinder delivery pipe has a separate and independent condenser, also a separate steam pipe, which renders the lubricator action for the cylinders entirely independent. An advantage is also believed to be obtained by a special water and oil trap in connection with the customary water tube leading to the bottom of the oil chamber. Its effect is to insure a positive supply of water and a uniform feed of the oil. A convenient feature of this lubricator is the arrangement of the valves. The adjustment of the feed is secured by means of the lower feed valves, C C, and once adjusted for the desired rate of feeding they need not be disturbed, because the lubricator is put into and out of operation by means of the ejector valves, D D. The body and all arms projecting from it are cast in a single piece, and the fittings are not screwed into the main casting. In this way a number of joints are avoided. Our engraving shows the location of the filling valve, B, the water valve, N, the oil index, and other parts. These lubricators are manufactured by the Wm. Powell Company, 2525 Spring Grove Avenue, Cincinnati, Ohio. This company also makes triple-sight feed lubricators.

PERSONALS.

Mr. George H. Hancock has been appointed Superintendent of Machinery of the St. Louis & San Francisco, with headquarters at Springfield, Mo., vice J. R. Groves, resigned.

Mr. Charles P. Savage has been appointed Purchasing Agent of the Erie & Wyoming Railway, also for the Pennsylvania Coal Company and the Dunmore Iron and Steel Company, with headquarters at Dunmore, Pa.

Mr. J. J. Thomas, Jr., Master Mechanic of the Tuscaloosa shops of the Mobile & Ohio, has been made Assistant to the Superintendent of Motive Power and Car Equipment, with headquarters at Mobile, Ala.

Mr. H. D. Norris has been appointed Acting Purchasing Agent of the Pere Marquette, with headquarters at Grand Rapids and Saginaw, Mich., in place of Mr. R. Wallace, resigned. In addition to his duties as Purchasing Agent he will have charge of the company's stores.

Mr. H. M. Carson, formerly Assistant Engineer of Motive Power of the Pennsylvania Railroad at Altoona, Pa., has been appointed Master Mechanic, with headquarters at Pittsburg, vice Mr. D. O. Shaver. Mr. Carson is one of the ablest and most promising of the younger men of the mechanical department of the Pennsylvania.

Mr. W. H. Marshall, Superintendent of Motive Power of the Lake Shore & Michigan Southern, has also been appointed Superintendent of Motive Power of the Lake Erie & Western, vice Mr. P. Reilly, resigned. Mr. Marshall will undoubtedly apply to this road the same methods of dealing with motive power questions that he has so successfully applied on the Lake Shore.

It is reported that Mr. T. S. Lloyd, Master Mechanic of the Chesapeake & Ohio, will succeed Mr. J. W. Fitzgibbon as Superintendent of Motive Power of the Delaware, Lackawanna & Western. Mr. Lloyd is 47 years old, and has been Master Mechanic of the Clifton Forge shops of the Chesapeake & Ohio, also the shops at Richmond, Va., since 1890, previous to which he held a like position on the Cincinnati Division. He has also been identified with the Erie and Pennsylvania railroads.

The following changes in the mechanical department of the Baltimore & Ohio are effective March 1st, 1900: The position of Master Mechanic at Grafton is abolished. Mr. P. Hayden is appointed General Foreman at Benwood, vice J. F. Prendergast, transferred. Mr. J. F. Prendergast is appointed General Foreman at Grafton, W. Va., vice P. Hayden. Mr. P. J. Harrigan is appointed General Foreman at Connellsville, Pa., vice D. Witherspoon, who has been appointed General Foreman at Cumberland, Md.

Addison C. Rand, President of the Rand Drill Company, who died recently at his home in New York City, was born in Westfield, Mass. Mr. Rand was a pioneer in the manufacture of steam drills and air-compressing plants, and had been one of the foremost in building up the great business of his house. He was one of the founders, and for some time Treasurer, of the Engineers' Club of New York City. He was also a member of the American Institute of Mining Engineers, and of the American Society of Civil Engineers.

Mr. Fayette S. Curtis, for 12 years Chief Engineer of the New York, New Haven & Hartford, has been elected Fourth Vice-President of that road. Mr. Curtis was born in Owego, N. Y., December 16, 1843, and was educated in the Owego Academy, taking a special course in civil engineering. After graduating in 1863 he was employed for eight years in the location and construction of various railroads. In 1871 he was employed by the Harlem River & Portchester Railroad in the location of a line between New Rochelle and the Harlem River. In 1874 he was appointed Chief Engineer of the New York & Harlem Railroad Company, continuing in this capacity until 1883, when he was appointed Chief Engineer of the New York, New Haven & Hartford.

John M. Holt, who has been for a number of years General Foreman of Car Repairs of the Southern Railway, died suddenly at Washington, D. C., February 25. Mr. Holt began his railroad career in 1865 as an apprentice in the car department of the Burlington shops of the old North Carolina Railroad, and when this road was absorbed by the Richmond & Danville he was transferred to the Manchester shops as Foreman of Car Repairs. Soon after the Richmond & Danville was incorporated in the Southern Railway he was appointed General Foreman of Car Repairs at Washington, D. C. Mr. Holt was a very able and successful man in his particular line of business, and commanded a reputation for fairness which made him well liked by all who knew him. He was an active member of the Master Car Builders' Association.

Charles H. Coster, whose recent death was so keenly felt, not only by the many prominent railroads of which he was a director, but by the corporate interests of this country, was born at Newport, R. I., July 24, 1852. He began his business career with a firm of importers in 1867. In the course of his business career his work has always been concerned with the larger commercial interests of the City of New York. He became a partner in the banking house of Drexel, Morgan & Co. in 1884 and was at the time of his death a partner in J. P. Morgan & Co., Drexel & Co., Morgan, Harjes & Co., and also a director of 46 of the most prominent railroads of this country. Several of the boards of directors of which he was a member, feeling the loss of so successful and upright a man, have placed on record their realization of the fact by appropriate resolutions. This is unusual, and is a high tribute to his memory.

BOOKS AND PAMPHLETS.

Interaction of Wheel and Rail. Translated from the German of Boedecker by A. Bewley, Public Works Department, India.

This work gives in three chapters a theoretical discussion of the relations between the wheels of railroad trains and the rails. It is a difficult mathematical subject, and the translator has been careful and thorough. The first chapter deals with the motion of single axles, the pressure and surface of contact of wheels and rails, and the friction of rolling. The second takes up the motion of four-wheel cars on curves and the third covers the same ground with locomotives having three pairs of wheels.

Nickel-Steel: A Synopsis of Experiment and Opinion. By David H. Browne, Cleveland, O., Head Chemist for the Canadian Copper Co. A paper presented to the American Institute of Mining Engineers at its California meeting, September, 1899.

This pamphlet of 80 pages contains the paper by Mr. Browne in advance of its publication in the transactions of the Institute. It is the most valuable treatment of the subject of nickel-steel that has ever appeared; in fact, it is a classic. Everyone who is interested in the design, construction or operation of machinery, and especially where strength, weight and ability to withstand repeated stresses are concerned, should procure a copy for study and reference.

Handbook and Illustrated Catalogue of Engineers' and Surveyors' Instruments of Precision. C. L. Berger & Sons, Boston, Mass.

This catalogue, 6 in. x 9 in., of 212 pages, including index, is bound in stiff boards and contains descriptions and illustrations of the latest styles and important improvements in the various instruments used by engineers and surveyors. Some of the more recent improvements which are illustrated in this catalogue are: A bracket by means of which the transit may be set up in narrow places, as in shafts of mines, where it is impossible to use an extension tripod; a short focus lens attachment which will admit of objects being focused at distances as close as three feet from the instrument, and many minor attachments and improvements for field instruments

used in astronomical observations. There are also given in this volume several chapters of valuable information concerning the care and adjustment of instruments.

Report of Tests Made by Prof. W. F. M. Goss on a Vertical Triple Expansion Crank and Fly Wheel Pumping Engine, Having a Daily Capacity of 20,000,000 Gallons.

A record of 167.8 million foot-pounds of work per 1,000 pounds of dry steam, as was shown by the Snow Pumping Engine at Indianapolis, Ind., in a duty test made by Prof. W. F. M. Goss, Purdue University, in 1898, has awakened the highest interest among engineers and users of pumping engines in this country as well as abroad. For those interested in pumping machinery the two complete tests made on this engine, one in July, 1898, and the second in December of the same year, have been printed and put in pamphlet form. We are indebted to Prof. Goss for a copy of these valuable and interesting reports, which are the best specimens of pumping engine testing of which we have record. There is also given in this pamphlet, by Mr. G. H. Barrus, M. E., Boston, Mass., a comparison of the performance of this engine with a number of other prominent engines which have been tested within the last six years.

Handbook of Testing Materials for the Constructor. By Prof. Adolf Martens, Director of the Royal Testing Laboratories at Berlin and at Charlottenburg. Translated by Gus. C. Henning, M. Am. Soc. M. E. 2 vols., cloth, 6 by 9 inches, 622 pages; illustrated. New York, 1899: John Wiley & Sons. Price of two vols., $7.50.

The author's preface states the object of the work as follows:

My book on Testing Materials for the Constructor is designed to be a counsellor to the constructor in all questions relating to the properties of his materials of construction. Therefore the book is divided into two volumes, each independent and complete in itself. This first volume relates to the general properties of materials of construction, and especially to the art and science of testing materials as applied to machinery and superstructure. To the description of the customary methods of testing I have added a presentation and discussion of the most important types of testing machines and auxiliary apparatus, dwelling mainly upon the underlying principles of design, sources of errors, and on their calibration. As this volume contains the manifold experiences of the laboratories under my direction, and as I have availed myself of the liberal arrangements granted by the publishers to fully illustrate, by figures and plates, the most important machines and instruments of all countries, I hope to produce a lasting benefit, not alone to my students, but also to manufacturers of apparatus, by my frank and candid criticism.

The translator states in his preface that he has faithfully followed the author and reproduced his thought in the hope of promoting greater uniformity in testing and more accurate knowledge of materials. He has done his work carefully and should be credited with giving readers of English a most excellent treatise on this subject which was not available in the language before. The separation of the engravings from the text and binding them in a separate volume seems, at first, very awkward, but it is really not so, particularly in the use of descriptions covering several pages and referring to a single engraving or group of engravings.

This work gives more information about testing, testing machines and incidentally about materials, than any book we have seen. We commend it to our readers who have to do with the testing of materials.

Steam Engine Theory and Practice. By William Ripper, University College, Sheffield, England. Published by Longmans, Green & Company, New York, 1899. 389 pages; illustrated. Price $2.50.

This modest work of scarcely 400 pages essays to comprehend the whole field of steam engine theory and practice. The purpose is an ambitious one, but the text is so very concise that the reader soon begins to wonder at the great degree of thoroughness which is secured in so limited a space. Mathematical expressions are not prominent, though the development of the usual thermodynamic relations are all presented, but in such good form and so intermingled with the descriptive matter as to relieve the book of that formidable appearance which often characterizes works upon similar subjects. Graphical presentations are numerous and interesting. The chapter on temperature-entropy diagrams, with a large plate by Captain Sankey, is of especial interest, and another on superheated steam, dealing with a subject which just now is much alive in England and on the Continent, is full and altogether satisfactory.

While the book is written by an Englishman and primarily for English students, it contains frequent references to American practice. For example, both the Carpenter and Peabody calorimeters are described; the John Fritz fly wheel is illustrated; the experiments on engine friction by Dr. Thurston are referred to, and the results of locomotive tests by Prof. Goss are discussed. The author's preface contains the following:

Special attention has been given to the subject of heat quantities involved in the generation and use of steam. For this purpose the temperature-entropy diagram has been used, and its applications in the solution of a number of ordinary every-day problems exemplified. The writer desires to express his personal indebtedness to Captain Sankey for his kindness in supplying him with copies of his temperature-entropy chart, which appears for the first time, as Plate I. of this book. This chart has gone through an interesting process of evolution since the occasion when Mr. J. Macfarlane Gray read his paper at the Paris meeting of the Institution of Mechanical Engineers in July 1889, on the "Rationalization of Regnault's Steam Experiments," describing and explaining the use of the steam and water lines of the temperature-entropy chart. Since that time Capt. Sankey has added lines of constant pressure, and constant volume in 1892; and more recently also the scales of total heat and internal energy, as well as the chart for the superheated steam field. All these additions now appear upon the chart as shown in this book.

The Steam Engine and Gas and Oil Engines. A book for the use of students who have time to make experiments and calculations. By John Perry, D. Sc., F. R. S., Professor of Mechanics and Mathematics, Royal College of Science. Published by The Macmillan Company, 66 Fifth Avenue, New York, 1899: Price, $3.25.

The plan of this excellent book contemplates a large amount of verification of the author's presentation by the student. It aims to induce the reader to investigate and work out problems for himself. The study by mere reading is discouraged and the student is urged to test the laws given by the philosophers. The portion devoted to the steam engine is one of the best treatments of the subject ever written, because it tends to stimulate thought and study rather than to assume an acceptance of what one is told by others. It is essentially devoted to the steam engine. The book is strong in its adherence to practical conditions of actual modern experience, and the considerations of questions which occur in the every day work of engineers. It is not a mathematical discussion. The author gives the first place in importance to the facts of experiment. He then brings mathematics to bear in accounting for and using them in study and design. The sensible use of simple mathematics is one of the striking features of the work. A large amount of space is given to the form instruction and arrangement of the detail of steam engines. The illustrations are better than those usually found in English works of this kind. The author, however, hesitated to describe "the old despised type of engine." It is not only the easiest to describe but the most important for the student to understand. The study of details and thermodynamics are combined as they have not been before. There is a good chapter on valve gears, one on balancing or governors, a satisfactory study of boilers and combustion.

It is essentially a book for students, but as the practicing engineer never ceases to be a student, it will be of great value to him. It contains a new analysis of the performance of the Willans engine. Its only serious fault is the omission of credit for the borrowings from the work of others.

"Centrifugal Ventilators," is the title of a pamphlet by J. T. Beard, presenting a mathematical study of the centrifugal fan with particular reference to its use for the ventilation of mines. It is published by The Colliery Engineer Co.

"Packings" and "Garden Hose" are the titles of two little pamphlets received from the Boston Belting Co., 256 Devonshire St., Boston, Mass. These present illustrations and printed descriptions of the many varieties of these products as manufactured by this well-known concern. They also contain the accessories, such as valves, wire rope sheave fillings, gage glass packings and the fittings for various kinds of rubber hose.

Coal Washing Machinery.—The Jeffrey Manufacturing Co. of Columbus, O., has issued a profusely illustrated pamphlet of 88 pages as a catalogue of coal washing and coal handling machinery. This company has developed a coal washing system with a view of placing before coal operators a comparatively low cost plant which will enable them to market the low grades of coal and greatly improve the quality of higher grades. The pamphlet presents a large number of engravings of plants in use giving photographs and line drawings. It also contains a reprint of a paper by J. J. Ormsbee, read before the American

Institute of Mining Engineers, in which the coal washing plant at No. 2 Slope, Pratt Mines, Alabama, is described. The results of the washing are given in detail, one of which was to reduce the amount of ash in the coal from 9.98 to 5.78 per cent. This paper is an interesting report on the washing of coal and is very satisfactory and complete. In addition to coal washing machinery, attention is given to retarding conveyors, steam coal tipples and the coal elevating and conveying machinery, in connection with which this company has become so well known.

"Our Railroads and Our Canals" is the title of an 18-page pamphlet containing a reprint of an address by Mr. George H. Daniels, General Passenger Agent of the New York Central Railroad, before the Chamber of Commerce of Utica, N. Y., February 19, 1900. It has been placed in the "Four Track Series" and presents a strong argument in favor of the railroads by showing that canal transportation has outlived its usefulness on account of the modern development of railroads. The closing paragraph of the address expressed the speaker's position in the following words:

> The day of the canal packet and the stage coach has gone by, never to return, notwithstanding the fact that in their day and generation they were of great value to the country; but a newer and better means has been found, more in keeping with the advancement of our people in all the arts and sciences; and if the American people will treat the railways with the same degree of justice that in the past they have treated their canals, our commerce will continue to expand, until we stand at the head of the commercial nations of the world.

It is understood that Messrs. W. H. Patterson and A. C. and D. W. McCord have secured control of the Illinois Car & Equipment Co. The English capital is still retained, but American interests have been added and hereafter the company is to be managed solely in this country. Mr. Patterson and Mr. A. C. McCord have recently returned from England, where the arrangements were consummated. The report that McCord & Company were to assume charge of the car company is erroneous and arose probably out of the fact that the officers of the two companies are practically identical. A working arrangement between the two companies has been effected whereby a part or all of the specialties of McCord & Company will be manufactured at the works of the car company. Various extensions and improvements in the plant are being made. For the present the work is to be confined to the construction of wooden cars, forgings and castings. Mr. L. Oberauer is retained as superintendent and Mr. D. L. Markle as assistant manager.

EQUIPMENT AND MANUFACTURING NOTES.

The number of students now enrolled in the International Correspondence Schools is 160,000, and it is constantly increasing.

The Navy Department has placed an order with the New York Air Compressor Company, 120 Liberty Street, New York, for two duplex compound air compressors of large capacity for the Charlestown Navy Yard, Boston, Mass.

The Robert Aitchison Perforated Metal Co., of Chicago, have moved their offices from 269 Dearborn Street to the Plymouth Building, 303 Dearborn Street, of that city. Their new quarters are much larger, more comfortable and more suitable than the former ones.

The "Consolidated Railway Electric Lighting & Equipment Co." is the name of the organization under which the American Railway Electric Light Co., the United Electric Co., the Columbian Electric Car Lighting and Brake Co., the Electric Axle Light and Power Co. and the European Railway Electric Lighting Co. have been amalgamated.

The Union Boiler Tube Cleaner Company of Pittsburg have issued circulars illustrating their very effective devices for cleaning the tubes of water-tube boilers, and giving records of tests of boilers of the Standard Oil Company, showing a saving of 24.8 per cent. in fuel as a result of cleaning tubes at their works. The construction and operation of the cleaning devices are described by aid of engravings made from photographs of actual work. The cleaning devices are adapted to curved as well as straight tubes.

A continuous exhibition of machinery and manufactures in New York City has been provided for by the International Land and Exhibition Co. in the Bowling Green Office Building. The object is to extend to every manufacturer the privilege of an office in New York, together with a show room for machinery in motion and in charge of experienced engineers and competent salesmen. The moderate rate of $6 per square foot per year is charged for the space and a number of important industries have already availed themselves of the opportunity. The plan is a large one, including representation in foreign countries. Mr. Albert Krimmert, President of the International Land and Exhibition Co., Bowling Green Offices, New York, should be addressed for further information.

The Ajax Metal Company have been conducting elaborate laboratory tests of bearing metals as a result of a series of experiments made upon the wearing qualities of bearing metals by officers of the Pennsylvania Railroad. Among other things these tests brought out the desirability of reducing the proportion of tin and increasing that of lead in the bearings up to a point where homogeneity was sacrificed. The Ajax people have been successful in this direction to the extent of reducing the proportion of tin from 8 to 5 per cent., and increasing the proportion of lead from 15 to 30 per cent., without sacrificing homogeneity. When compared with phosphor-bronze these proportions of tin and lead gave less than one-third of the wear and 20 per cent less rise in temperature from friction.

Mr. J. W. Lowell has been appointed manager of the railroad department of the Manhattan Rubber Manufacturing Co., of 18 Vesey St., New York. He has been connected with the mechanical department of the Pennsylvania Railroad for eight years, two years as draftsman and six years in the test department. This company has decided upon an increased activity in the manufacture and sale of air brake hose and mechanical rubber specialties for the railroads. Mr. Lowell will be a valuable addition to the staff because of his practical railroad experience and technical education. He learned the machinist's trade in the shops of the Baltimore & Ohio R. R. at Baltimore and afterward served on the civil engineering staff of the Baltimore Belt line. Before entering the service of the Pennsylvania he was connected with the engineering department of the Maryland Steel Co. at Sparrows Point.

The product known as Warren's Liquid Pulley Cover has created considerable interest and we are asked what it is. It is not a belt dressing, but a pulley paint for which the claim is made that it will prevent belts from slipping and retain its effectiveness for years. It is made by the Warren Manufacturing Co., 36 Jackson Street, Chicago. Its object is to furnish to a smooth wood or iron pulley a surface which has a natural affinity for the belt. It is accomplished by painting the face of the pulley with a liquid which may be applied with a brush and will become dry in about two hours. The manufacturers have so much confidence in the qualities of this material as a preventive of the slipping of belts that they are willing to send it on trial. A pulley cover which will do away with the danger, expense and annoyance of slipping belts must prove advantageous in every establishment where belts are used. Attempts to prevent slipping usually take the form of excessive tightening and, assuming that sufficient adhesion is obtained in this way, the excessive strain on the belt must increase the friction on the bearings and the expense of lubrication. It not only adds to the loss of power, but tends to throw the shafting out of line and greatly decreases the life of the belts. If the adhesion, under the increased tension, is still insufficient to prevent slipping, heat is generated even with a very slight amount of slip, and the belt loses its natural oil and its life will be short. Cases of fire have been known to arise from this source, an instance having recently occurred at the works of the American Steel & Wire Co., at Waukegan, Ill., in which the loss was heavy. Furthermore a belt which slips is a constant souree of loss of power. The manufacturers are very careful to state that this is not a sticky preparation which requires work to be done to make the belt and pulley separate as the pulley revolves. If this liquid pulley cover is all that is claimed for it by users, it is an admirable substitute for the leather lagging which has been used extensively in a great many kinds of machinery. The Warren Manufacturing Co. will furnish complete information concerning this product, which is rapidly taking a place among the staple supplies of the important manufacturing establishments throughout the country